SCIENCE 14

MODULE 2: TECHNOLOGY IN ACTION

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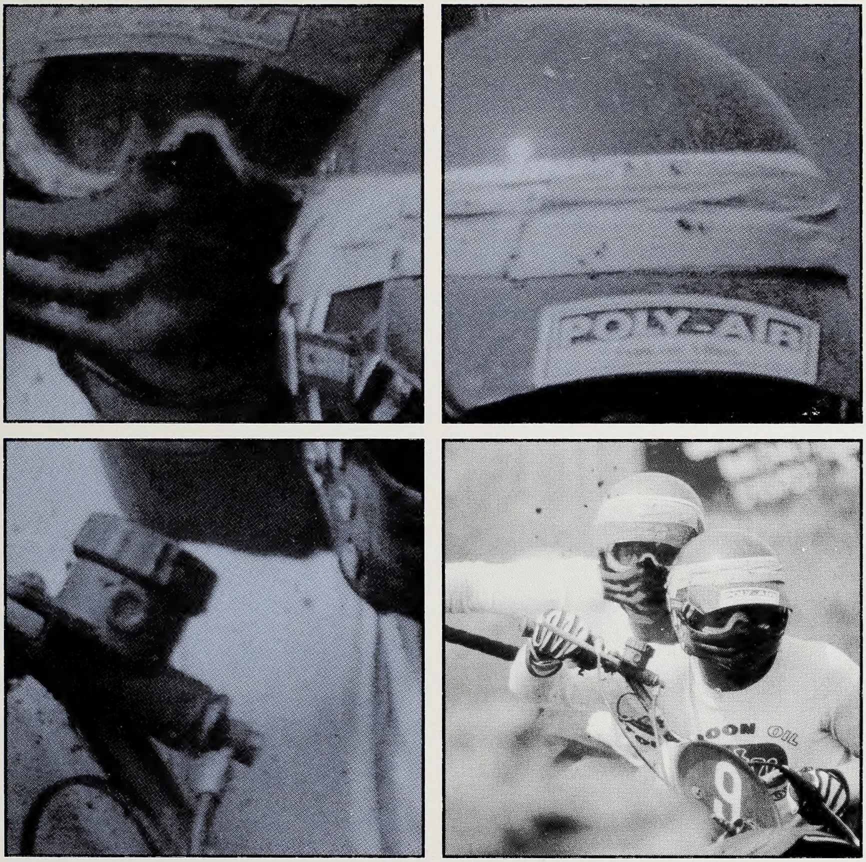

Distance Learning

Alberta
EDUCATION

Science 14

Module 2

TECHNOLOGY IN ACTION

Distance Learning

Alberta EDUCATION

Science 14
Student Module
Module 2
Technology in Action
Alberta Distance Learning Centre
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Welcome to Module 2!

We hope you'll enjoy your study of Technology in Action.

To make your learning a bit easier, a teacher will help guide you through the material.

So whenever you see this icon,

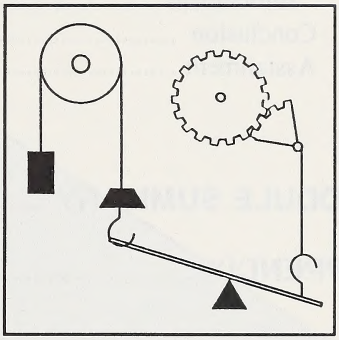
turn on your audiocassette and listen.

Contents

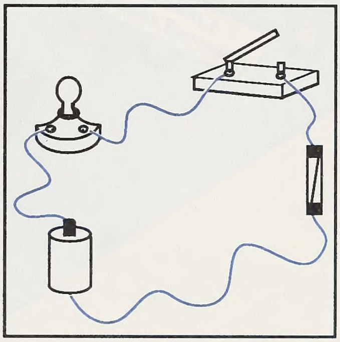
OVERVIEW 1

Evaluation 2

SECTION 1:
SIMPLE MACHINES 3
Activity 1: Levers 5
Activity 2: Inclined Planes 20
Activity 3: Pulleys and Gears 30
Follow-up Activities 37
Extra Help 37
Enrichment 42
Conclusion 45
Assignment 45

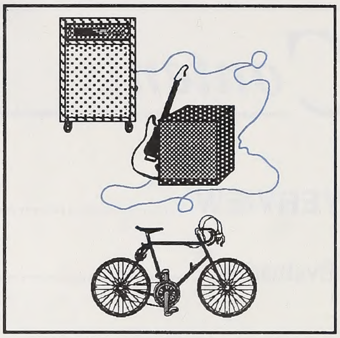


SECTION 2:
ELECTRICITY AND MAGNETISM 47
Activity 1: Static Electricity 49
Activity 2: Current Electricity 55
Activity 3: Some Electrical Devices 62
Activity 4: Magnets 69
Activity 5: The Electromagnetic Devices 78
Follow-up Activities 85
Extra Help 85
Enrichment 89
Conclusion 92
Assignment 93



SECTION 3:

COMPLEX TECHNOLOGY – A CASE STUDY 95
Activity 1: The Guitar Itself 97
Activity 2: Amplifying the Sound 102
Activity 3: The Whole System 106
Activity 4: The Bicycle (Gears) 110
Activity 5: Friction 115
Activity 6: Going for a Ride 119
Follow-up Activities 123
Extra Help 123
Enrichment 124
Conclusion 125
Assignment 125



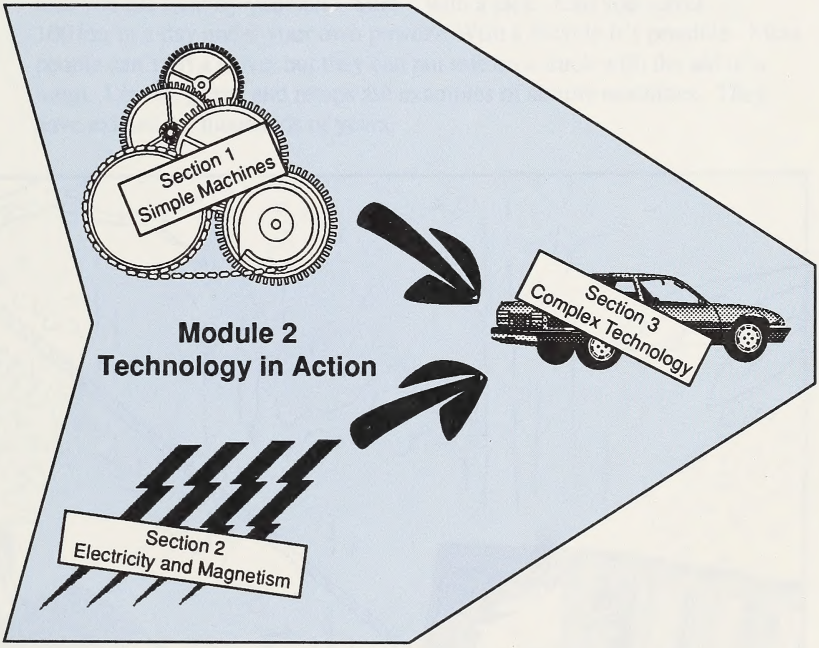
MODULE SUMMARY 126

APPENDIX 127

OVERVIEW

People have used their knowledge of nature to develop very complex technologies. This module looks at two technologies that are very common to everyone, and it shows how they are used to make more complex devices. In this module you should

- understand the different simple machines
- take a look at how electricity works
- do a case study of one complex device



Evaluation

Your mark in this module will be determined by your work in the Assignment Booklet. You must complete all assignments. In this module you are expected to complete three section assignments. The assignment breakdown is as follows:

Section 1	=	35 marks
Section 2	=	35 marks
Section 3	=	30 marks
TOTAL	=	100 marks

Section

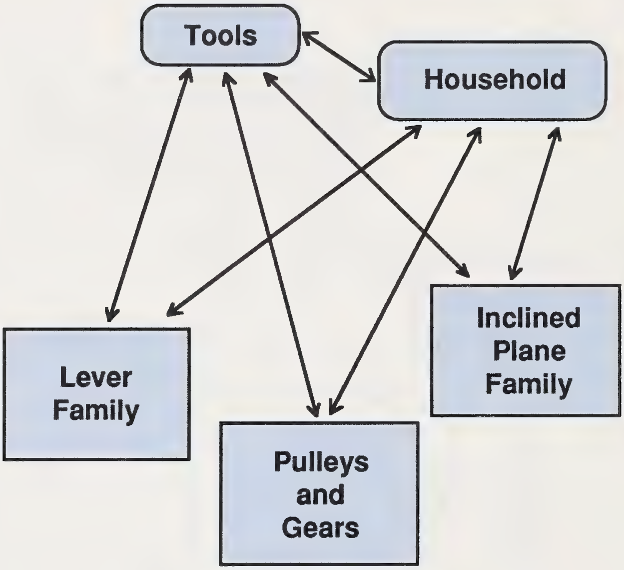
1 Simple Machines

Can you lift a car by yourself? Sure – with a jack. Can you travel 100 km in a day under your own power? With a bicycle it's possible. Most people can't lift a stove, but they can put one on a truck with the aid of a ramp. Levers, gears, and ramps are examples of simple machines. They have existed for thousands of years.

By the end of this section you should be able to

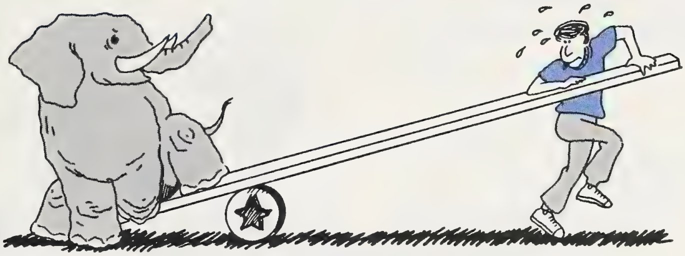
- understand the basic types of simple machines
- know some laws that simple machines work with
- recognize simple machines in your daily life

Study this diagram. It may help you organize your thoughts around this unit.



Activity 1: Levers

Give me a long stick.

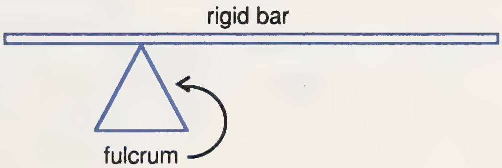


lever - a rigid bar turning on a balance point (fulcrum)

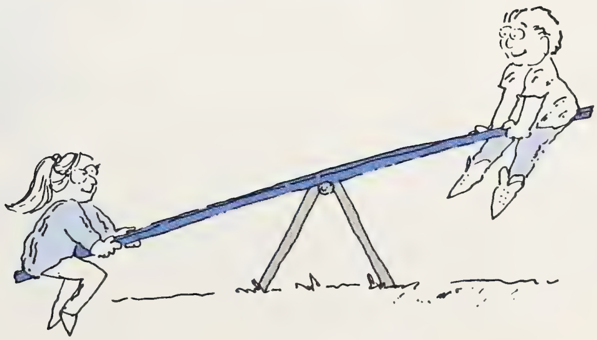
fulcrum - the balance or pivot point of a lever

A **lever** is a stick and a balance point. Actually, it's any solid bar turning on some balance point. The balance point is called a **fulcrum**. Levers are everywhere. You probably use at least one every day.

A Lever (in theory)



A Lever (in practice)

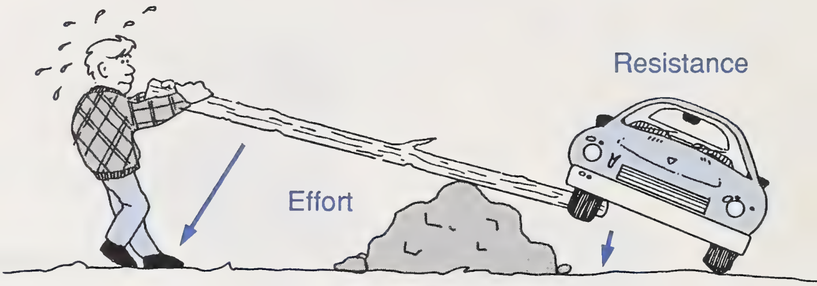


effort - force exerted by a person using a machine

force - a push or pull usually measured in newtons
A baseball weights about 1 N.

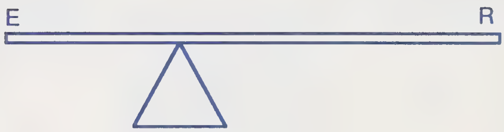
resistance - the force you try to overcome with a machine

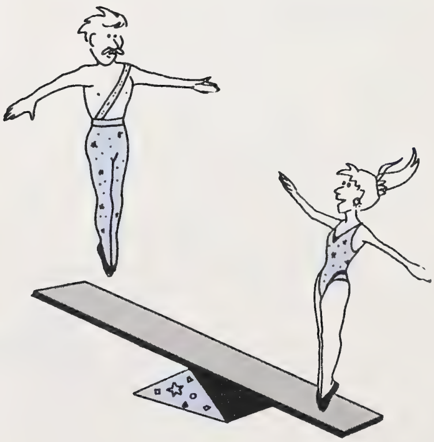
When levers are in use, you push on one side and lift something on the other side. The **force** that you apply is called the **effort**. The force you are working against is called the **resistance** (or load).



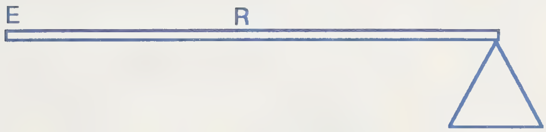
The fulcrum can be anywhere on the lever. Levers can be classified according to where the fulcrum is. What a lever can do for you also depends on where the fulcrum is.

FIRST-CLASS LEVER – FULCRUM IN THE MIDDLE

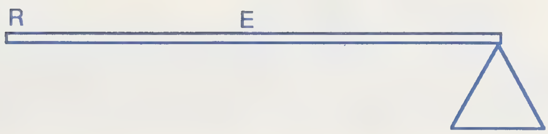




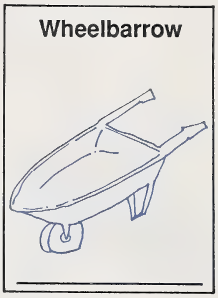
SECOND-CLASS LEVER – RESISTANCE IN THE MIDDLE

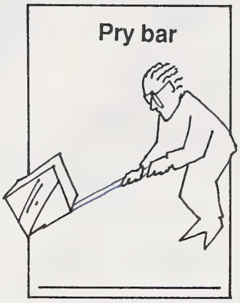


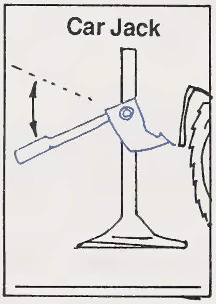
THIRD-CLASS LEVER – EFFORT IN THE MIDDLE



1. These are all pictures of levers. Classify them as first-class, second-class, or third-class levers.



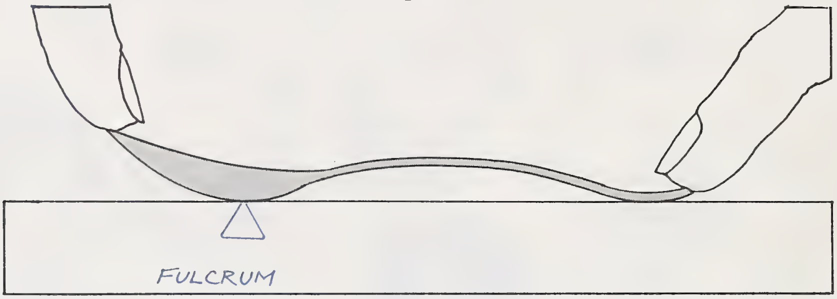




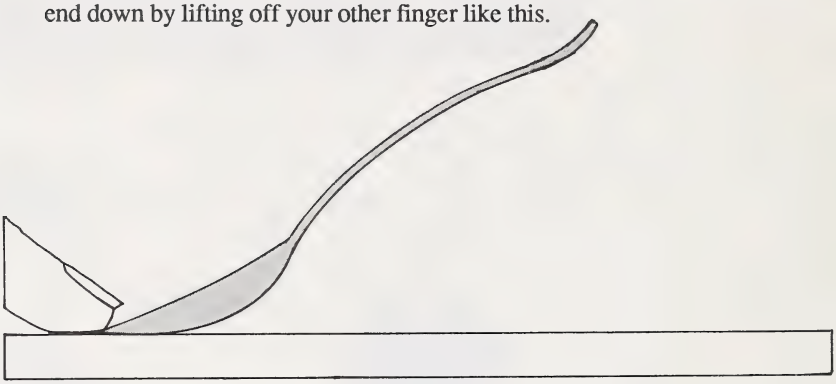
When you use any simple machine you are trying to do one of two things; either making your work easier, or making the resistance move fast or far.


That's only a ruler and an eraser!
Yes but I'll balance the ruler on the eraser, and it will become a lever.
So, what are you going to do with it?
Oh!

This dialogue brings up an important point. Anything can become a lever if it's used as one. Take a look at a spoon.



Push down on both ends of a spoon. (Don't push too hard and bend it!) Can the finger on the eating end lift the other end of the spoon? Push the eating end down by lifting off your other finger like this.



Now try to hold the eating end down while you push with the other finger on the other end.

2. Which end is easier to push?

____

____

3. Why doesn't the eating end stay down when you push on the other end?

____

____

____

4. Why can't you lift the handle by pushing on the eating end if your finger is on the handle end?

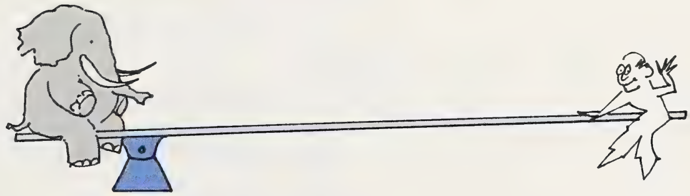
____

____

____

Check your answers by turning to the Appendix, Section 1: Activity 1.

The next investigation shows that the distance a force is from the fulcrum is important in determining the effect the force has.



Investigation: Is There a Relationship Between the Distance from a Fulcrum and the Effect of the Force at That Position?

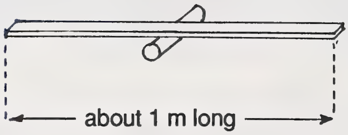
Materials You Need

- a stick (a metre stick is good, but anything will do)
- sixteen small weights (pennies, washers, etc.)
- a fulcrum (frying pan handle or something similar)
- ruler

Steps to Follow

STEP A

Set up your lever as shown. Put the fulcrum in the middle and balance it.



STEP B

Place eight weights 20 cm to one side of the fulcrum. Try to balance it with eight weights on the other side. Mark **where** they must be placed.

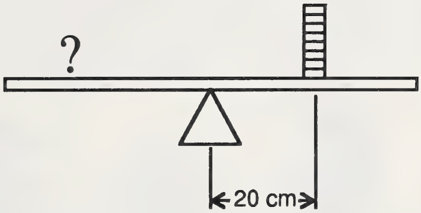
STEP C

Try to balance the first set of eight weights with four other weights and then with six other weights. Mark the places where they must be placed.

STEP D

Measure the distances that you marked on steps B and C. Fill in the observation chart that follows.

Observations



Number of Weights	Distance from Fulcrum (cm)	Number of Weights	Distance from Fulcrum (cm)
8	______	8	20
4	______	8	20
6	______	8	20

Conclusion

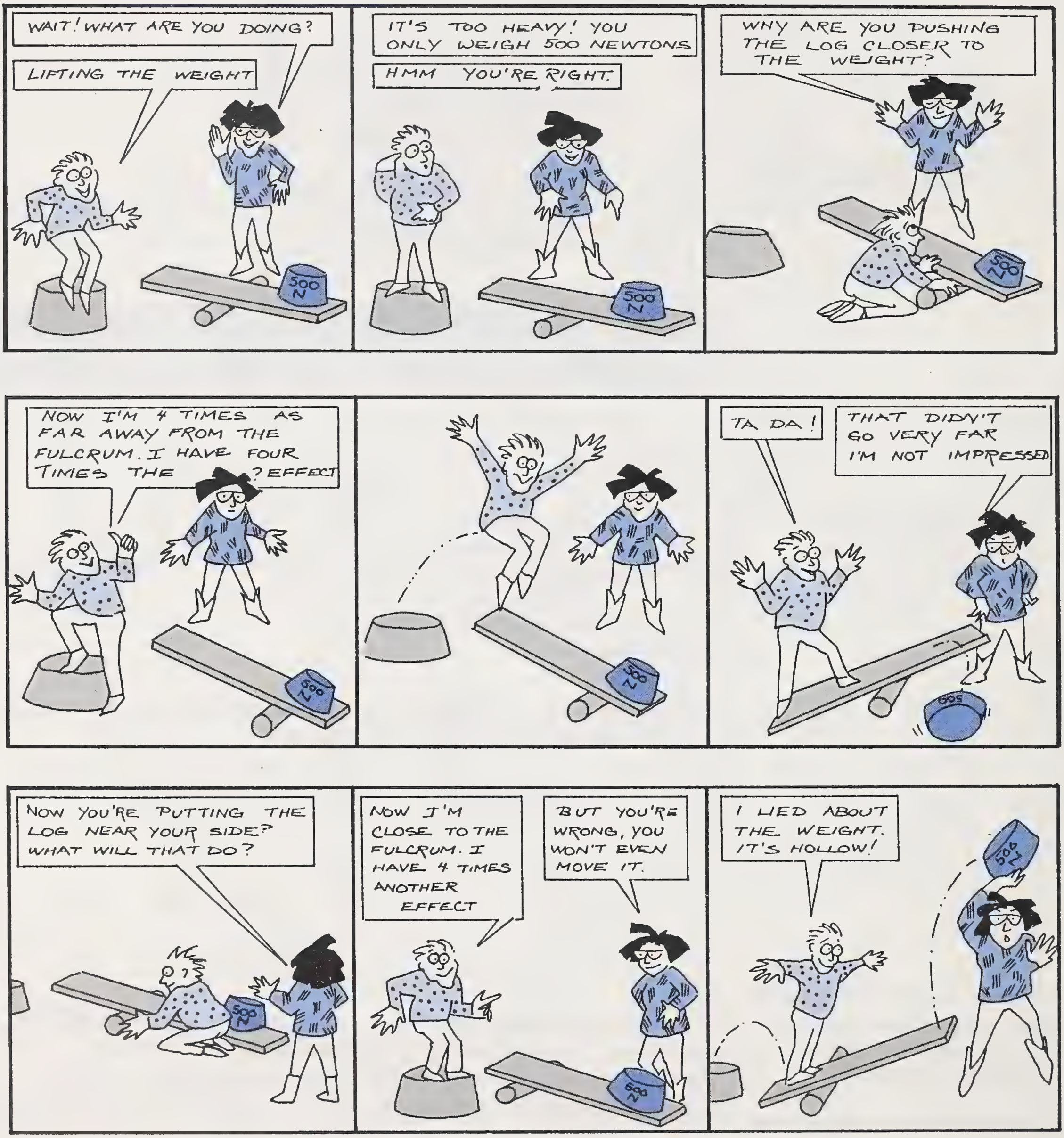
Multiply the number of weights by the number of centimetres the weights are away from the fulcrum for each part of the chart.

weights × distance	weights × distance
8 × ______ = ______	$8 \times 20 = 160$
4 × ______ = ______	$8 \times 20 = 160$
6 × ______ = ______	$8 \times 20 = 160$

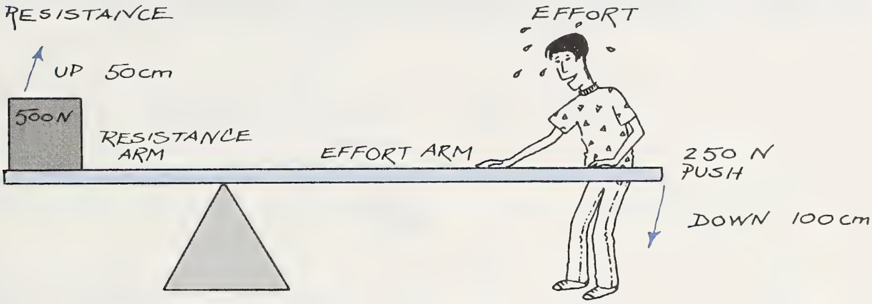
force - a push or a pull Force is usually measured in newtons. A baseball weighs about 1 N.

The weights represent forces. Force × distance is the same on both sides of the fulcrum. You can check this conclusion by placing different combinations of weights on both sides of the fulcrum. Force × distance should be the same on both sides (or within a reasonable experimental error).

Check your answers by turning to the Appendix, Section 1: Activity 1.


WAIT! WHAT ARE YOU DOING?
LIFTING THE WEIGHT
IT'S TOO HEAVY! YOU ONLY WEIGH 500 NEWTONS
HMM YOU'RE RIGHT.
WHY ARE YOU PUSHING THE LOG CLOSER TO THE WEIGHT?
500 N
NOW I'M 4 TIMES AS FAR AWAY FROM THE FULCRUM. I HAVE FOUR TIMES THE ? EFFECT
TA DA!
THAT DIDN'T GO VERY FAR I'M NOT IMPRESSED
NOW YOU'RE PUTTING THE LOG NEAR YOUR SIDE? WHAT WILL THAT DO?
NOW I'M CLOSE TO THE FULCRUM. I HAVE 4 TIMES ANOTHER EFFECT
BUT YOU'RE WRONG, YOU WON'T EVEN MOVE IT.
I LIED ABOUT THE WEIGHT. IT'S HOLLOW!

If you can lift a weight (say 500 N) with a force of 250 N, then the lever makes the work twice as easy. The trade-off is that the thing you are lifting will go up only half as far as you push down.



Again – if you multiply the force × distance moved for both sides of the lever, you get the same number on both sides.

5. Do the multiplications for the example shown above.

	Force × distance =
Resistance arm	
Effort arm	

mechanical advantage - a measurement showing how much easier your work is; ratio of $\frac{\text{resistance}}{\text{effort}}$ for any simple machine

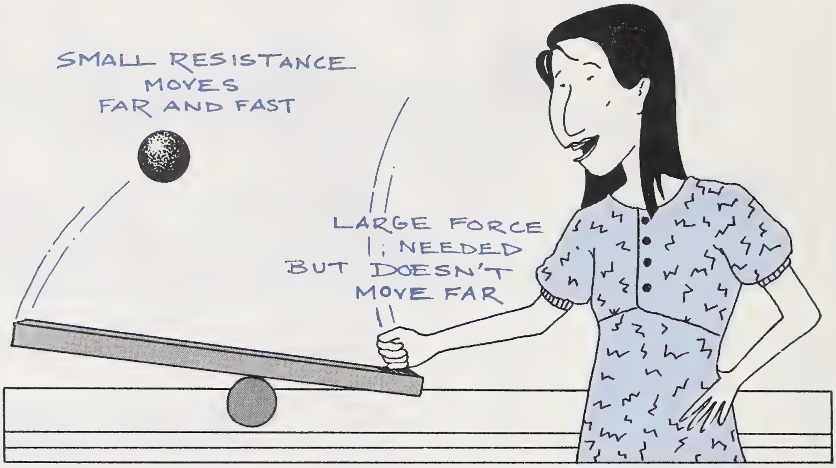
The ratio of the $\frac{\text{Resistance}}{\text{Effort}}$ is called the **mechanical advantage** of the lever.

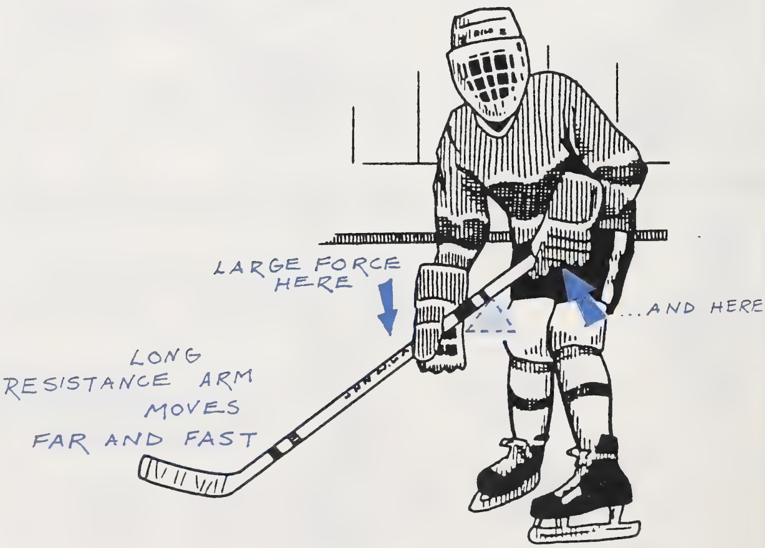
The previous example has a mechanical advantage of $\frac{\text{Resistance}}{\text{Effort}} = \frac{500\text{ N}}{250\text{ N}} = 2$.

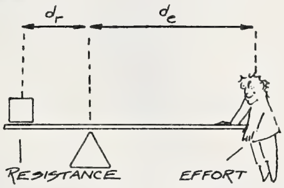
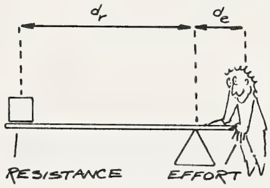
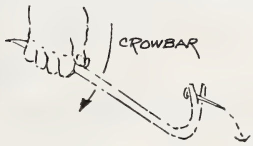
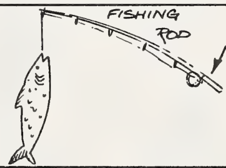
Notice that mechanical advantage (M.A.) has no unit at all. It's a measurement that shows how many times easier it is to do a task.

6. Changing a car tire involves lifting one-quarter of the car's weight. This can be 3000 N (about 300 kg). Suppose that a car jack is a lever with an M.A. of ten. With what force would you have to push down on the jack to lift the car?

Some levers have mechanical advantages less than one. (See the last three boxes in the comic strip.) This means that you must push with a large force to move a small resistance. Why do that? The answer is in how far the resistance moves. It will move further than you push.

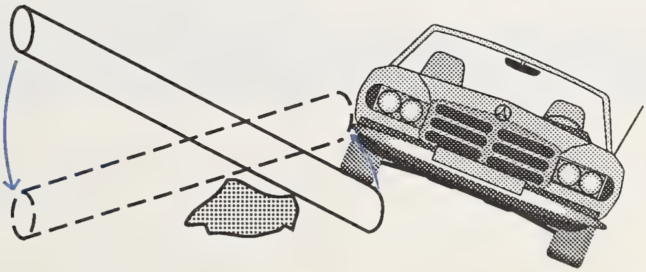




Mechanical Advantage Greater than One	**Mechanical Advantage Less than One**
• gain force • lose distance	• gain distance • lose force
	
Resistance arm (d_r) short Effort arm (d_e) long	Resistance arm (d_r) long Effort arm (d_e) short
	

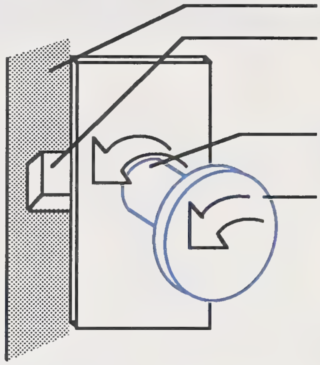
The comic strip shows a first-class lever with a mechanical advantage greater than one, and then less than one. Second-class levers only have mechanical advantages greater than one. Third-class levers only have mechanical advantages less than one.

If you look closely as a lever moves, you'll notice that it rotates around the fulcrum.

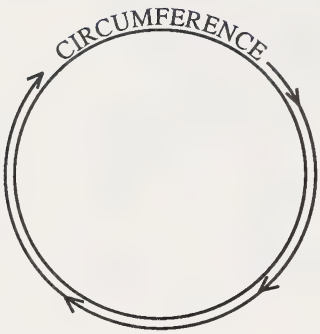


wheel and axle - a type of lever consisting of two wheels on the same axis

If you wrap a lever into a circle you have a **wheel and axle**, another of the simple machines. A doorknob is one example of this.



circumference - the distance around a circle



Since the **circumference** of the *effort arm* (the handle) is larger than the circumference of the *resistance arm* (the shaft), the doorknob has a mechanical advantage greater than one. (It takes less force to turn the handle than to push the door latch into the doorjamb.)

7. Name the wheel and axle described in each of the following descriptions. They can be found around most houses.

   a. turns bolts into a hole ______________________

   b. a toy with two wheels on an axle on a string ______________

   c. with a turn it changes the amount of light in a room __________

   ____

Do either question 8 or question 9.

Toolbox

8. Examine a toolbox and find four examples of levers. State whether the mechanical advantage of each is greater or less than one. You may include any wheel and axle devices as well.

   - ________________________________
   - ________________________________
   - ________________________________
   - ________________________________

Kitchen

9. Examine the utensils in a kitchen and find four examples of levers. State whether the mechanical advantage of each is greater or less than one. You may include wheel and axle devices as well.

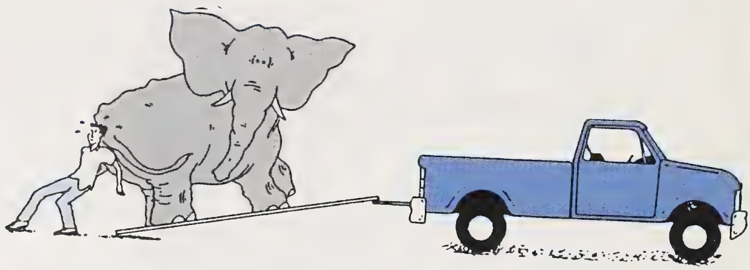
- ______________________________
- ______________________________
- ______________________________
- ______________________________

Check your answers by turning to the Appendix, Section 1: Activity 1.

inclined plane - a simple machine consisting of a flat surface set at an angle

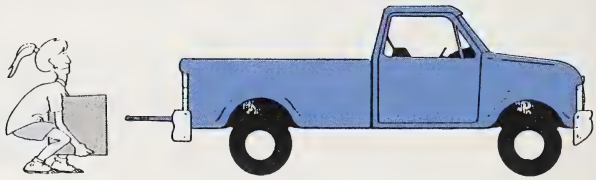
Activity 2: Inclined Planes

Haul it up the Ramp



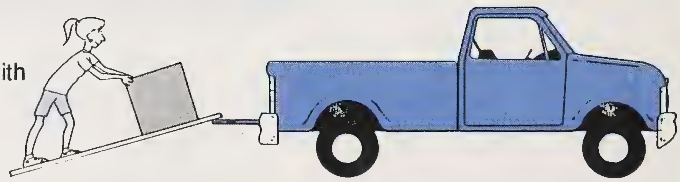
A plane is a flat surface. An **inclined plane** is a flat surface set at an angle. It is a simple machine. Think about loading a stove on a truck. The quickest way to do this would be to lift it straight onto the truck, but who can lift a stove? Using a ramp, one person can do it, but the stove must travel a greater distance.

Lift a short distance with a large force.



OR

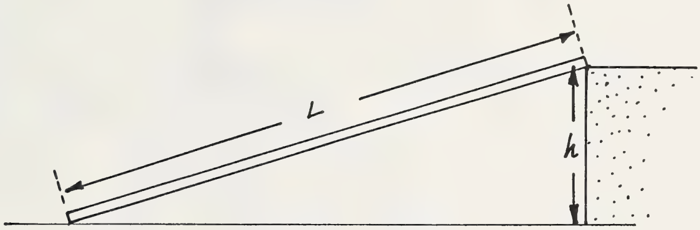
Push it a longer distance with a smaller force.



Inclined planes make your work easier. The effort is less than the resistance (weight of the object to be moved).

1. The mechanical advantage of an inclined plane is (greater/less) than one. (circle one)

   The parts of an inclined plane are given in the following diagram.



L is the length of the inclined plane.
h is the height that it is set at.

In theory, the mechanical advantage of an inclined plane is equal to its $\frac{\text{length}}{\text{height}}$.

Investigation: To Find the Mechanical Advantage of an Inclined Plane

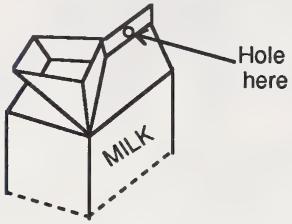
Materials You Need

- flat board (about 1 m long, if possible)
- some books (or anything else) to rest one end of the board on
- ruler
- empty 1 L or 2 L milk carton
- elastic band (long ones are the best)
- water

Steps to Follow

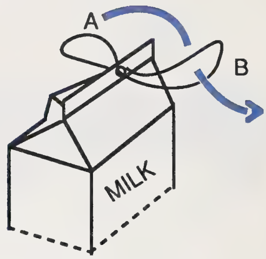
STEP A

Cut a hole in the top of the carton as shown. You should be able to open and close the carton without disturbing the hole.



STEP B

Attach the elastic band by looping it through itself. Loop A through B.



STEP C

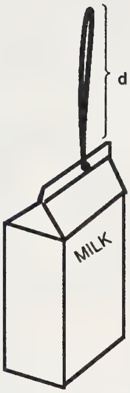
Pull the elastic tight against the hole.

STEP D

Add enough water to the milk carton to stretch the elastic about half of its full stretch when hanging up the container. You now have a force-measuring device.

STEP E

The stretch of the elastic is a measure of the force on it. Measure the stretch of the hanging container. This is your resistance.



OBSERVATIONS

Record the following measurements in centimetres (cm).

Resistance Stretch

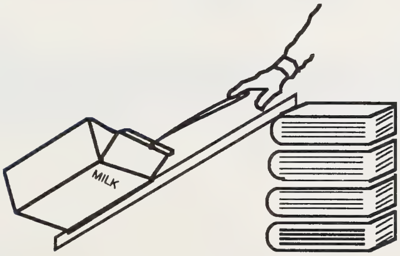
= ______________________

Length of Ramp

= ______________________

STEP F

Lay your ramp down on a few books. Lay the container down (spout side up). Pull the container up the ramp and record the stretch (d) and height (h) under the observations for Trial 1.



OBSERVATIONS

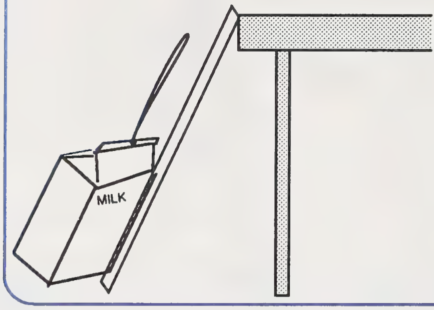
Trial 1

stretch: ______________ cm

height: ______________ cm

STEP G

Repeat the experiment three times, increasing the height of the ramp by adding books or by leaning the ramp on chairs, tables, etc. The ramp should be very steep for your last trial. Keep recording the distance that the elastic is stretched and the heights the ramp is raised.



OBSERVATIONS

Trial 2

stretch: ______________ cm

height: ______________ cm

Trial 3

stretch: ______________ cm

height: ______________ cm

Trial 4

stretch: ______________ cm

height: ______________ cm

Conclusion

2. What happens to the stretch as your inclined plane gets steeper?

____

____

____

3. Does the stretch going up the inclined plane ever come close to the resistance stretch?

____

If so, when?

____

____

work - the application of a force through a distance

When you multiply force × distance you are calculating the amount of **work** done. Find the work done with and without the ramp.

	With the ramp	Without the ramp
	The work, force × distance, is the pulling stretch × the length of the ramp.	The work, force × distance, is the resistance stretch × height.
Trial 1		
Trial 2		
Trial 3		
Trial 4		

4. Compare the work done with the ramp to the work done without the ramp.

____

____

____

____

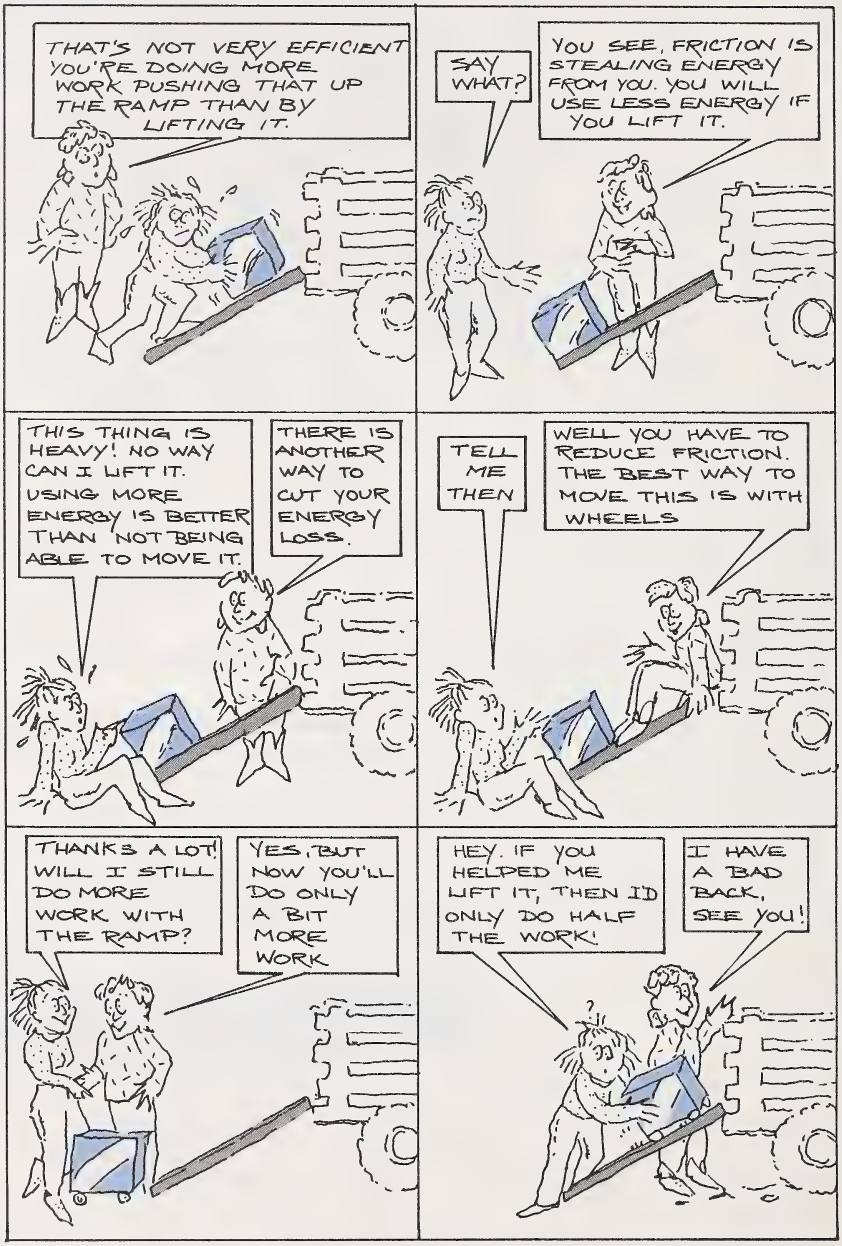
5. How do you explain the relationship between work done with and without the ramp?

____

____

____

Check your answers by turning to the Appendix, Section 1: Activity 2.


THAT'S NOT VERY EFFICIENT YOU'RE DOING MORE WORK PUSHING THAT UP THE RAMP THAN BY LIFTING IT.
SAY WHAT?
YOU SEE, FRICTION IS STEALING ENERGY FROM YOU. YOU WILL USE LESS ENERGY IF YOU LIFT IT.
THIS THING IS HEAVY! NO WAY CAN I LIFT IT. USING MORE ENERGY IS BETTER THAN NOT BEING ABLE TO MOVE IT.
THERE IS ANOTHER WAY TO CUT YOUR ENERGY LOSS.
TELL ME THEN
WELL YOU HAVE TO REDUCE FRICTION. THE BEST WAY TO MOVE THIS IS WITH WHEELS
THANKS A LOT! WILL I STILL DO MORE WORK WITH THE RAMP?
YES, BUT NOW YOU'LL DO ONLY A BIT MORE WORK
HEY. IF YOU HELPED ME LIFT IT, THEN I'D ONLY DO HALF THE WORK!
I HAVE A BAD BACK, SEE YOU!

6. Suppose you are lifting a 500 N object a distance of 1 m. You use a 3 m long ramp to do this. If your effort is 250 N, then what is the mechanical advantage of your ramp?

____

____

____

7. What should the mechanical advantage be in theory?

____

____

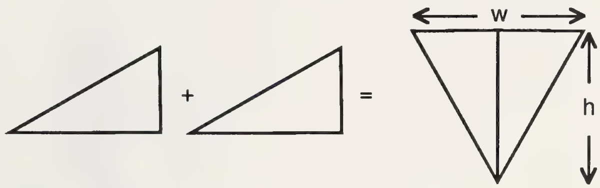
____

efficiency - measure of the energy loss of a machine; 100 percent efficient = no energy loss

wedge - an inclined plane (or planes) used as a moving part to exert a force at right angles to its motion

When you don't get all the mechanical advantage that you should, your machine isn't 100 percent **efficient**. No machine is 100 percent efficient. It's impossible.

If you put two inclined planes together (or just use one) and use it in a certain way, you get a **wedge**.



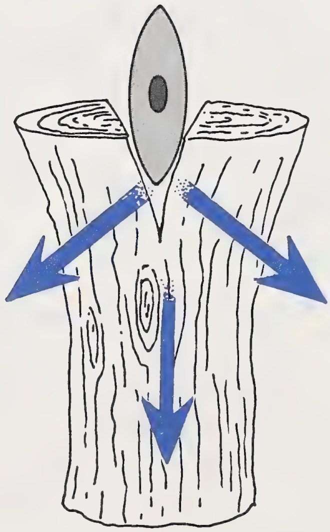
w = width **h** = height

The mechanical advantage should be equal to the $\frac{\text{height}}{\text{width}}$.

It is always greater than one. Knife blades, axe blades, and nails are examples of wedges.

Could you split this log with your bare hands?

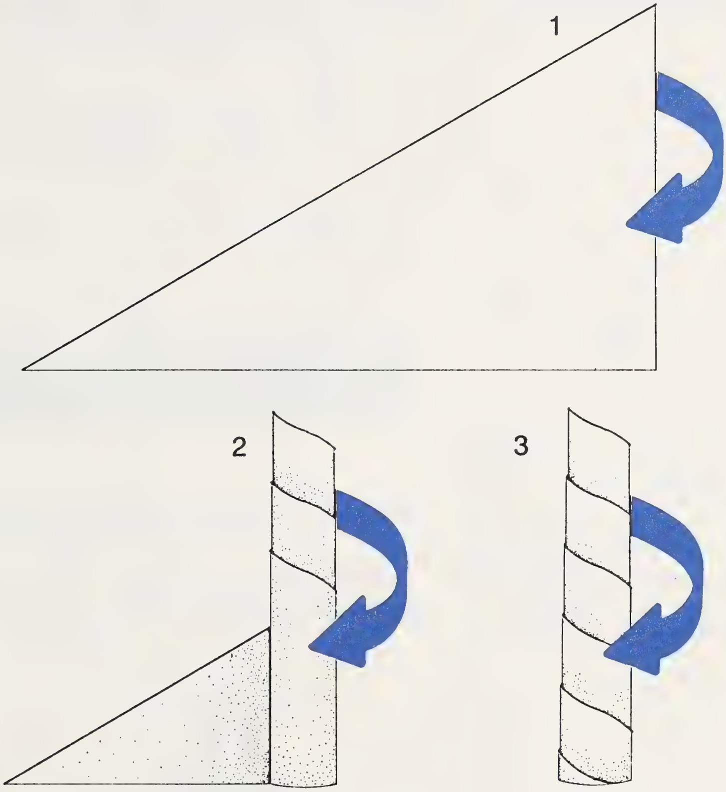
The wedge can because of its mechanical advantage.



The sideways force is huge! The log splits.

The force down is fairly large.

You can roll an inclined plane up, too.



screw - an inclined plane wrapped around a shaft

The result is a screw.

Do either question 8 or question 9.

Toolbox

8. Examine a toolbox and find two examples of wedges, and two examples of screws.

wedge • ____________________

• ____________________

screw • ____________________

• ____________________

Kitchen

9. Examine kitchen utensils and find two examples of wedges, and two examples of screws.

wedge • ____________________

• ____________________

screw • ____________________

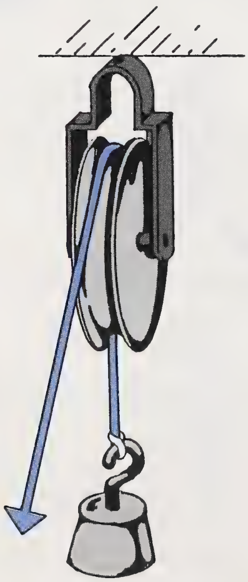
• ____________________

Check your answers by turning to the Appendix, Section 1: Activity 2.

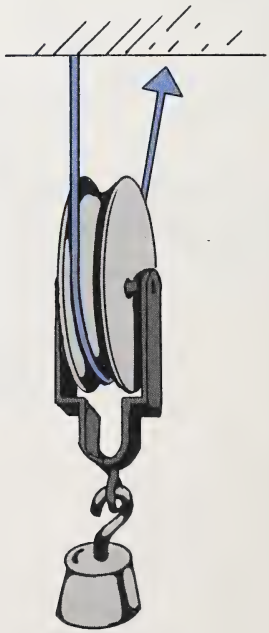
Activity 3: Pulleys and Gears

pulley - a wheel with a rope around it

A wheel with a rope or belt over it is a pulley. There are two kinds of pulleys, fixed and moveable.



Fixed Pulley



Moveable Pulley

friction - a force caused by surfaces sliding past each other (Air is a surface.)

A fixed pulley has a mechanical advantage of one. It doesn't gain or lose force or distance. (It actually may lose some force because of friction.) Its job is to change the direction of forces or allow you to lift things higher or lower than you can reach.

Fixed Pulleys – Uses

Awkward Lift

Lifts as high as the pulley.

1. Here are two examples of the pulley principle being used to lift an object.

a. What is the difference between them?

____

____

b. Which is easier to use?

____

____

c. Why?

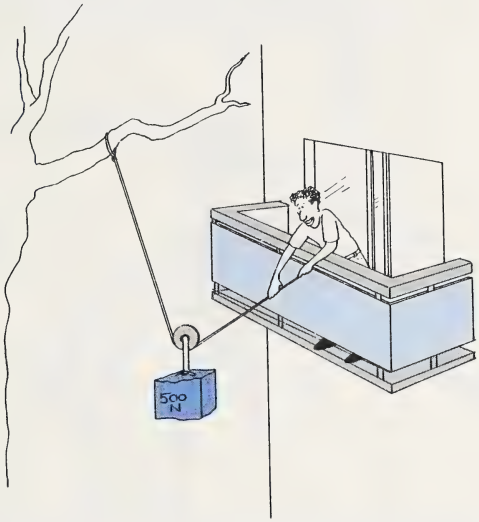
____

____

Refer to the next diagram.

When you use a moveable pulley your task is easier because you exert less force. However, you must exert this force over a greater distance.

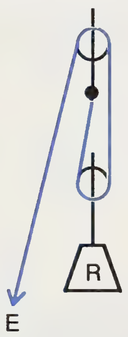
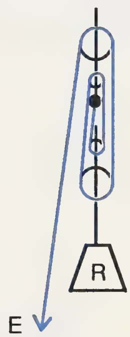
Moveable Pulley in Use



A force of about 250 N is needed to lift the box.

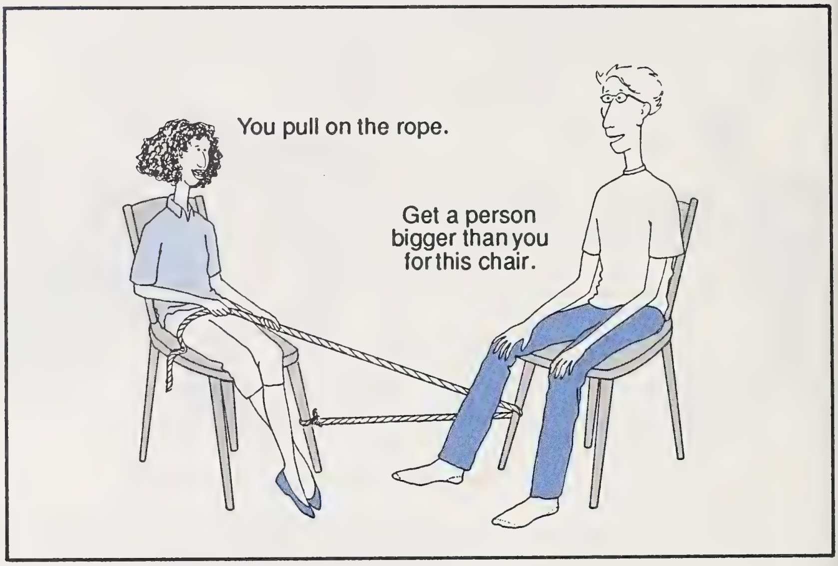
M.A. = 2

A block and tackle is a system of fixed and moveable pulleys. They can have very high mechanical advantages.

		
M.A. = 2 Effort is one-half of resistance.	M.A. = 3 Effort is one-third of resistance.	M.A. = 4 Effort is one-fourth of resistance.

If you have access to a set of pulleys, try to build the three block and tackle set-ups shown. Use your elastic band and milk carton force-measurer to check the mechanical advantages. They will probably be less than the values shown because of friction in the pulleys.

Get a rope and try this demonstration.



2. a. Which chair moves toward the other?

____

b. Why?

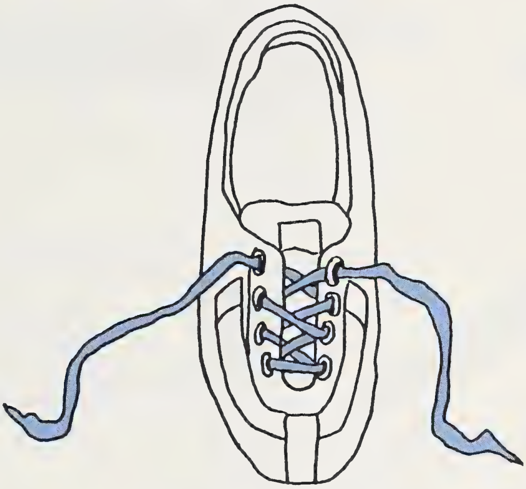
____

____

____

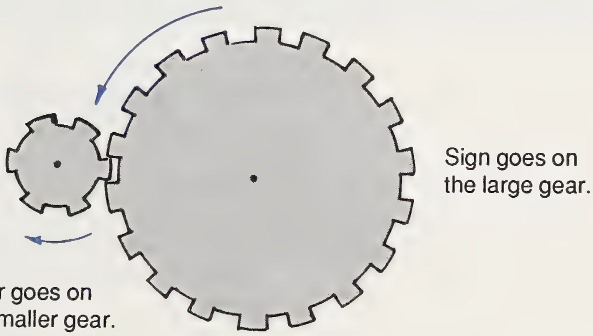
Check your answers by turning to the Appendix, Section 1: Activity 3.

Examples of pulleys in a household are not very numerous. Curtains sometimes have pulleys on them, and clotheslines also use them. Here is an example of moveable pulleys connected to moveable pulleys.

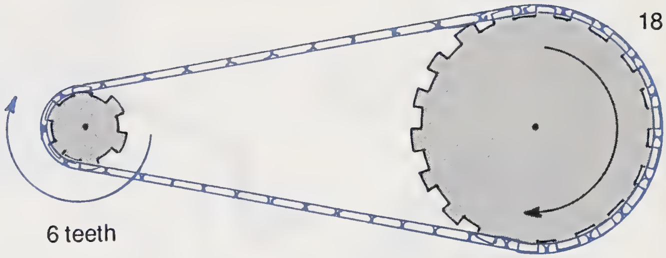


The mechanical advantage is large, even with all the friction present, so that you can pull the shoe tight to your foot. To pull the shoes closed, which is a very small distance, you have to pull the strings quite far.

Gears are toothed wheels connected to other gears, either directly or with a chain. Suppose you want to use a fast-moving motor to move a sign slowly. You could use gears to change the speed.



The teeth of the gears must fit into each other. The small gear has six teeth, the large one has eighteen. This means that the small gear turns three times in order to turn the large gear once. The speed of the sign is one-third of the motor's speed.



A chain may be used to keep the teeth in step. The speed of the sign would again be one-third of the motor's speed, but the sign would turn in the opposite direction.

3. Suppose you wanted the sign to move faster than the motor. How could you do this with the same gears?

____

____

____

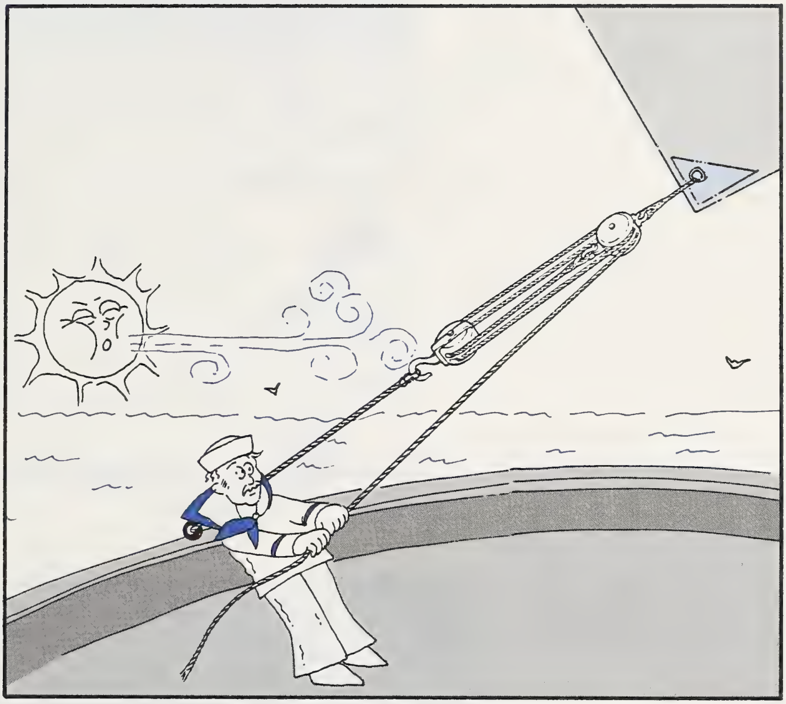
Gears are everywhere. They are easy to spot. Examine a bicycle, motorcycle, small toy, can opener, or clock. You will probably find some gears. If you break a toy or power tool by accident, don't throw it away. Take it apart and examine it. See if you can find the gears and figure out how they work.

4. Block and tackle systems are common on larger sailing boats. Sea cadets are quite familiar with them. Why are they so useful on a sailboat?

____

____

____



Check your answers by turning to the Appendix, Section 1: Activity 3.

Follow-up Activities

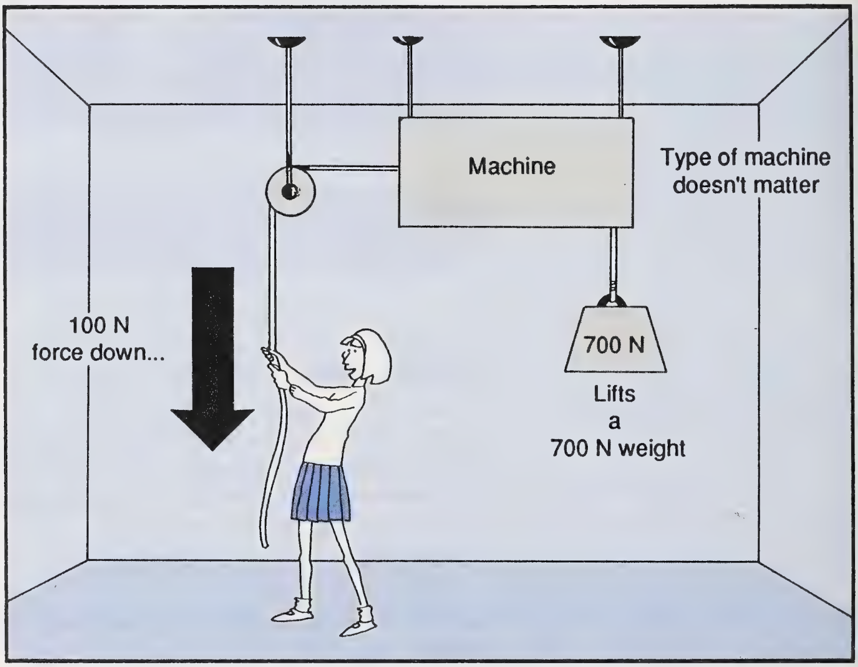
If you had difficulties understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

Look at this chart. It lists the types of simple machines developed in this section.

Type of Machine	Examples
Lever	shovel, wheelbarrow, seesaw
Wheel and Axle	doorknob, screwdriver handle
Inclined Plane	ramp
Wedge	knife blade, chisel
Screw	corkscrew, jar lid
Pulley	clothesline, curtains
Gears	clocks, cars, bikes

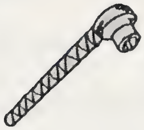
Mechanical advantage is a measurement showing how much easier a machine makes your work.

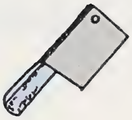


$$\frac{\text{Resistance}}{\text{Effort}} = \frac{700\text{ N}}{100\text{ N}} = 7 = \text{Mechanical Advantage}$$

1. Name the type of simple machine found in each of the following devices:

   a. nutcracker  ______________________

   b. socket wrench  ______________________

   c. meat cleaver  ______________________

   d. ramp ______________________

   e. bolt  ______________________

2. A car jack has a mechanical advantage that is quite large. Suppose you can push with a 250 N force, but you must lift 3500 N of weight to change a tire. What mechanical advantage do you need?

   ____

   ____

   ____

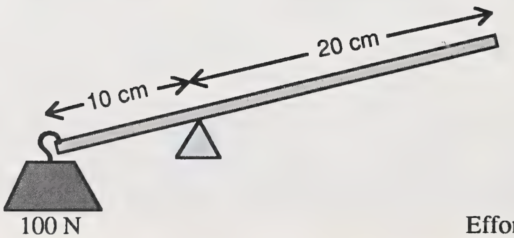
   ____

Use this chart to answer question 3.

Type of Machine	Important Considerations	Working Principle
Lever	• distance from fulcrum • size of forces	force × distance is equal on both sides
Wheel and Axle	diameters of the wheel and the axle	ratio of diameters is M.A.
Inclined Plane	height and length	$\frac{\text{length}}{\text{height}} = \text{M.A.}$
Wedge	width and length	$\frac{\text{length}}{\text{width}} = \text{M.A.}$
Pulley	fixed or moveable	M.A. = 2 or 3 for moveable pulleys
Gears	number of teeth	ratio of number of teeth = M.A.

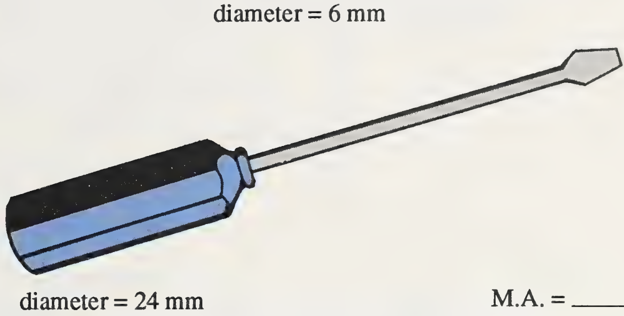
3. Fill in the blanks in these diagrams.

a.



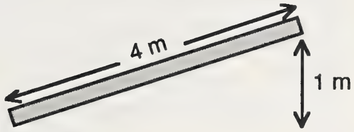
Effort = ____________

b.



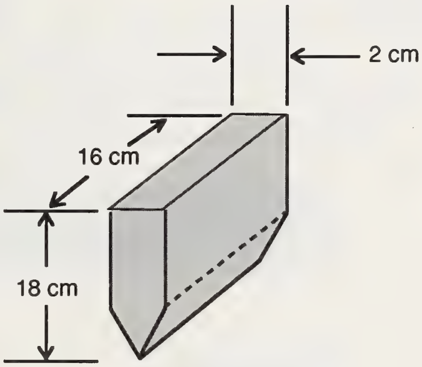
M.A. = ___________

c.



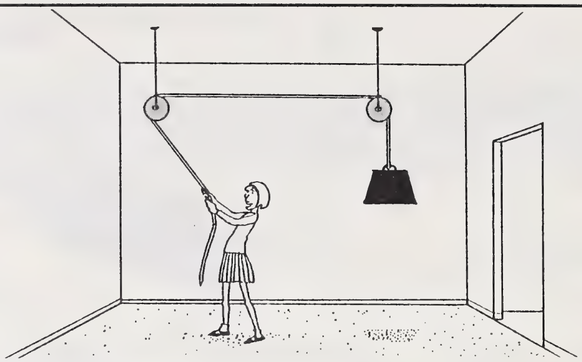
Force needed to push a 100 N weight up the ramp is ___________.

d.



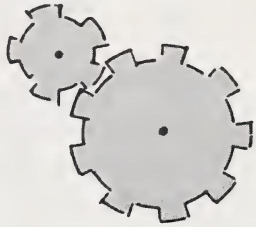
M.A. = ___________

e.



Type of pulleys ____________

f.



Gear ratio (large to small) is? ____________

Check your answers by turning to the Appendix, Section 1: Extra Help.

Enrichment

1. Try to go one day **without** using any simple machine. Watch yourself very carefully. Can you do it?

____

____

____

2. Investigate the gears of a derailleur-type bicycle. (ten-speed, twelve-speed, etc.) Are all the gear ratios different?

Materials You Need

- bicycle with derailleur gears
- chalk

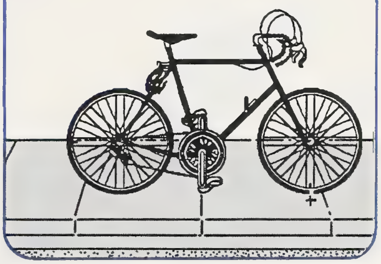
Steps to Follow

STEP A

Count the number of teeth on each sprocket of the bicycle. (A ten-speed has two front sprockets and five rear sprockets.) Put the bike into high gear (large front and small rear sprockets).

STEP B

Put a chalk mark on the front tire and on a sidewalk. Line up the marks.



STEP C

Push the bike forward, turning the pedals with your hand. Turn the pedals one full turn. Watch how many turns the front tire makes.

STEP D

Record how many turns the front tire went.

STEP E

Divide the number of teeth in the front sprocket by the number of teeth in the rear sprocket.

STEP F

Switch the rear sprocket and repeat steps C-E. Switch the front sprocket and do the rear sprockets again.

Observations

Front sprocket gears – number of teeth ______ , ______ , ______

Rear sprocket gears – number of teeth ______ , ______ , ______ ,

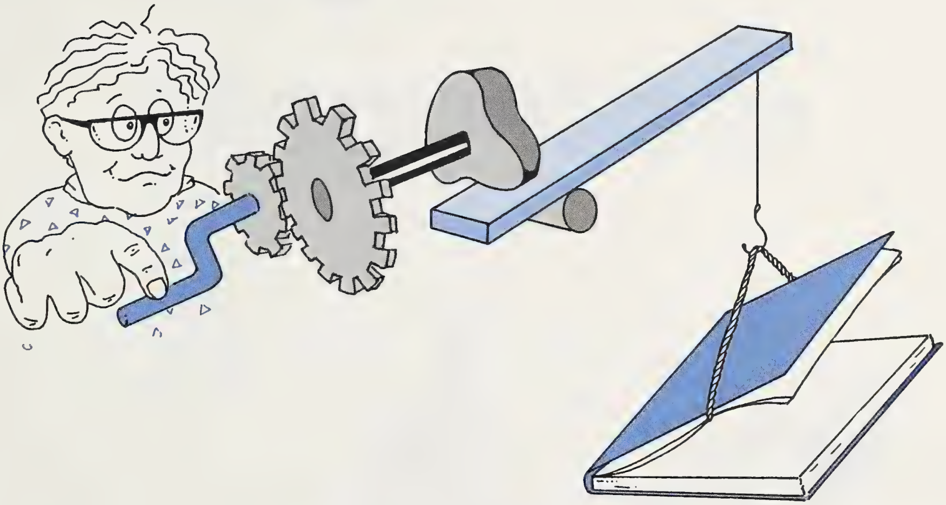
______ , ______ , ______

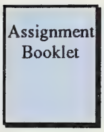
Gear combination	Gear ratio = front ÷ back	Number of turns of wheel

Check your answers by turning to the Appendix, Section 1: Enrichment.

Conclusion

You studied several kinds of simple machines in this section. You learned some working principles about most of them. You saw many examples of these machines at work in a typical house.



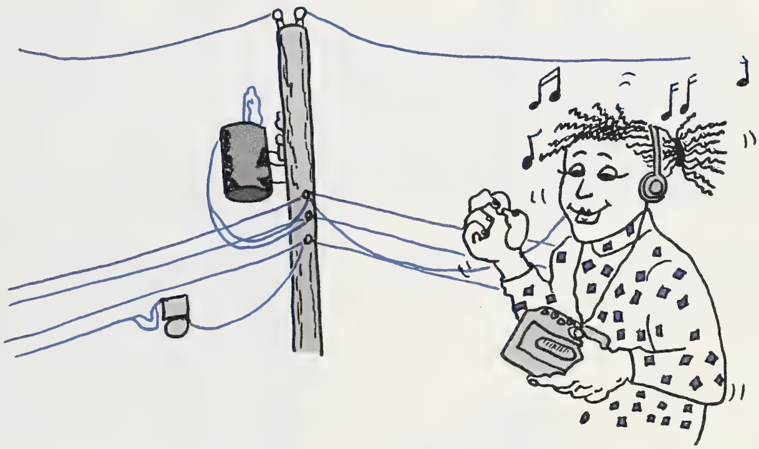


ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 1.

Section

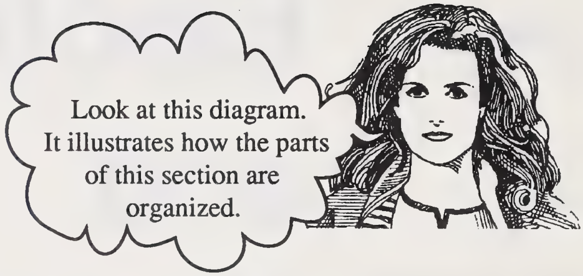
2 Electricity and Magnetism

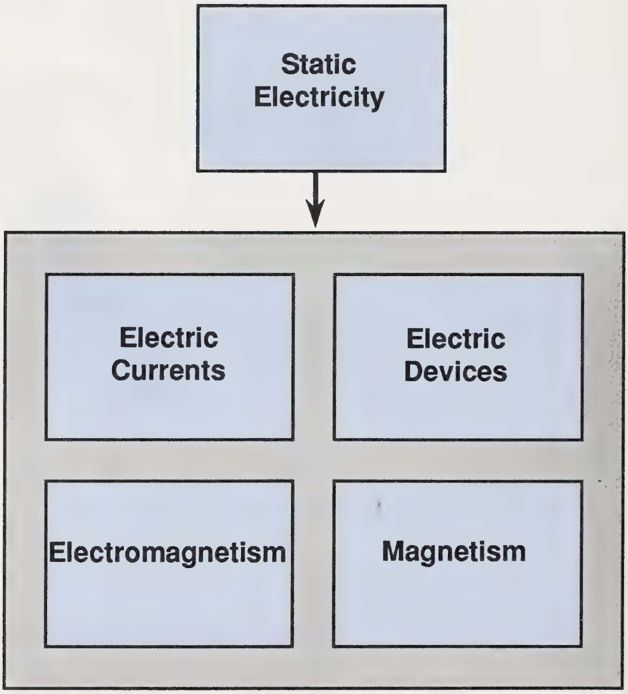


Can you imagine life without electricity? No stereos, lights, or TVs? What percentage of the things you use, use electricity? In this section you will study what electricity is and how it relates to magnets. You will also look at some electrical devices.

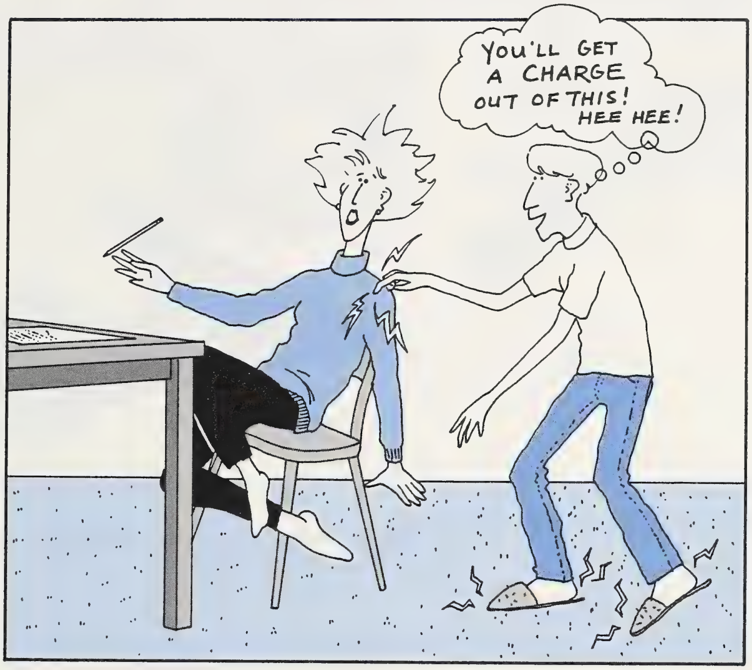
At the end of this section you should be able to

- describe what electricity is
- explain how electricity and magnetism relate
- know how some electrical devices work

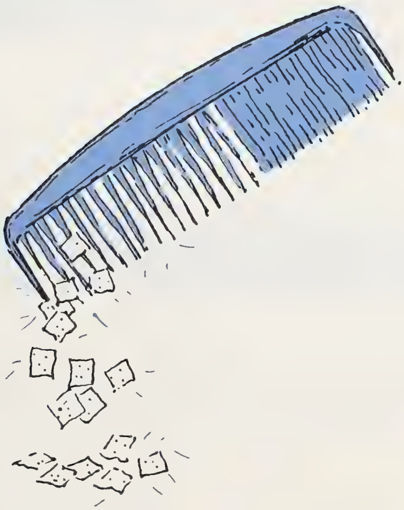

Look at this diagram.
It illustrates how the parts
of this section are
organized.


Static Electricity
Electric Currents
Electric Devices
Electromagnetism
Magnetism

Activity 1: Static Electricity



When some things are rubbed, they pick up a static charge. They will then attract light objects like paper, seeds, straw, etc. Try running a comb through your hair and holding it near some small bits of paper. It should pick them up.

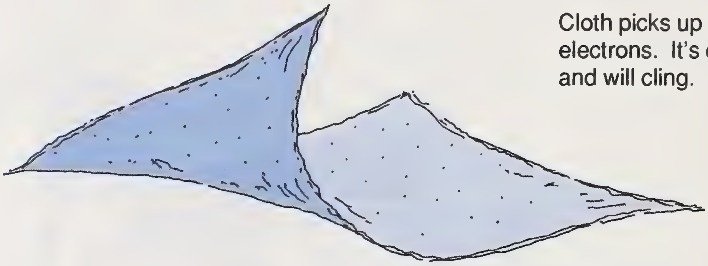


electron - a negatively charged sub-atomic particle responsible for electricity

electric charge - an excess or shortage of electrons in some location

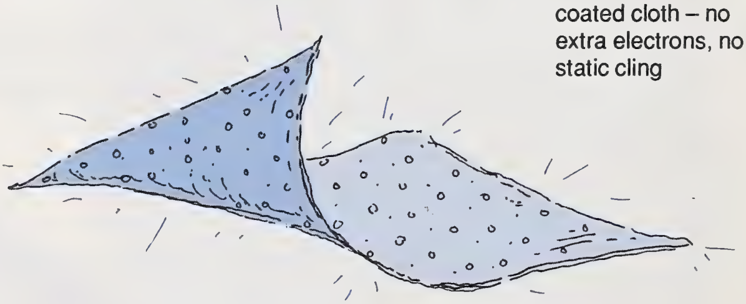
When rubbing the comb, **electrons** from your hair are pulled onto the comb giving it an **electric charge**.

Static electric charges are useful in some places and annoying in others. A clothes dryer tumbles clothes together and they pick up static charges (static cling). This annoys people so they often use anti-static devices in the dryer to prevent the buildup.



Cloth picks up extra electrons. It's charged and will cling.

Anti-static spray or cloth coats the clothes with chemicals that makes them give up the extra electrons.



coated cloth – no extra electrons, no static cling

Some people are allergic to the anti-static chemicals; they can't use them.

1. Try these tests with static electricity.

   a. Comb your hair and bring the comb near a trickle of water. What happens?

____

____

____

   b. Take some clothes with static on them into a dark closet and pull them apart. What do you see?

____

____

   c. Rub your feet on a rug, and then touch a metal object. What happens?

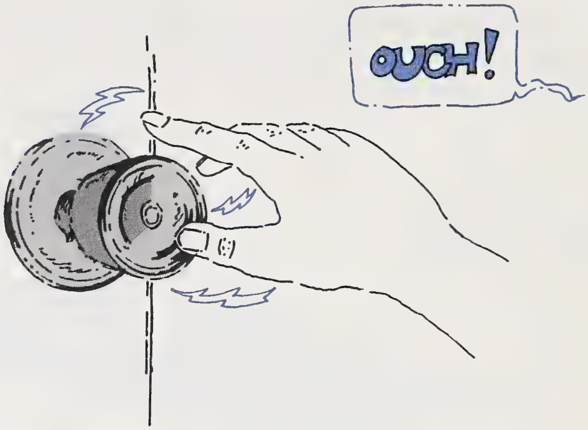
____

____

Check your answers by turning to the Appendix, Section 2: Activity 1.

When you get a shock, the extra electrons in one place jump to another place to even out their numbers. The more electrons that jump, the more energy that is moved.

A Small Static Spark



A Large Static Spark

Lightning is a huge static spark. Except for its size, it's the same as any shock you might get. However, lightning kills! Some buildings today are protected with lightning rods.

The rod ends deep enough underground to be in damp earth. If lightning strikes, it hits the rod and travels down a copper pipe until it's deep underground. The building isn't damaged.

conductor - a substance that lets electrons (electricity) flow through it

insulator - a substance that does not allow electrons (electricity) to flow through it

The reason lightning travels through a metal rod is that metal is a **conductor** of electricity. Substances such as glass are **insulators** – they don't let electricity flow. There are two kinds of electric charges.

Negative charge → **Extra electrons**

Positive charge → **Not enough electrons**

2. If a positive charge is near a negative charge, what do you think might happen?

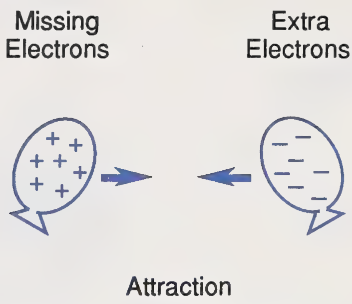
____

____

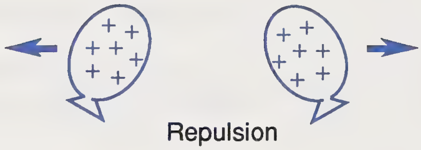
____

____

When opposite charges come close there is an attraction between them.



When like charges come close there is a repulsion between them.



3. If two negatively charged balloons drifted close together, what would they do?

____

____

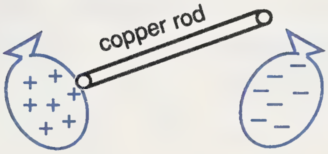
4. Look at this diagram. Predict what will happen when the glass rod touches both balloons?

____

____

____

5. In this case a copper rod is used. Predict what will happen when the copper rod touches both balloons?



Check your answers by turning to the Appendix, Section 2: Activity 1.

If you want to see a spark carry a metal spoon, rub your feet on a carpet and slowly approach a metal object. You should see the spark when the spoon is about 2 mm away from the metal object. The spark will be more visible in a dark room.

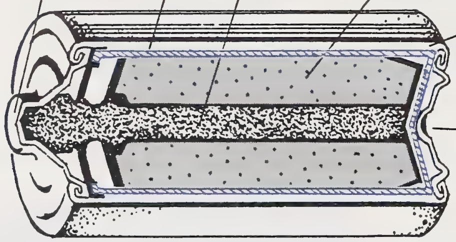
Activity 2: Current Electricity

Caution

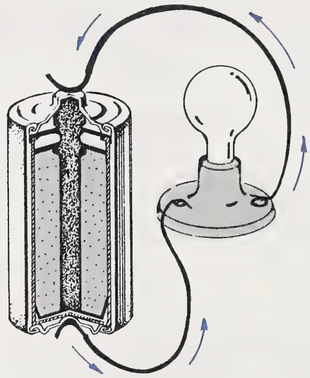
Never put any metallic object in an electric outlet. Household current can kill.

battery (cell) - a device that produces electric current by changing chemical energy to electrical energy

When electrons have a path to travel, they move from where there is an excess of electrons to where there is a shortage of electrons. A **battery** (electric cell) maintains an excess of electrons at one terminal and a shortage at the other terminal.



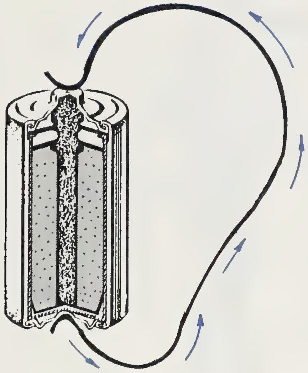
When a battery is part of a circuit, electrons move from the negative terminal, where there is an excess of electrons, through the circuit to the positive terminal, where there is a shortage of electrons.

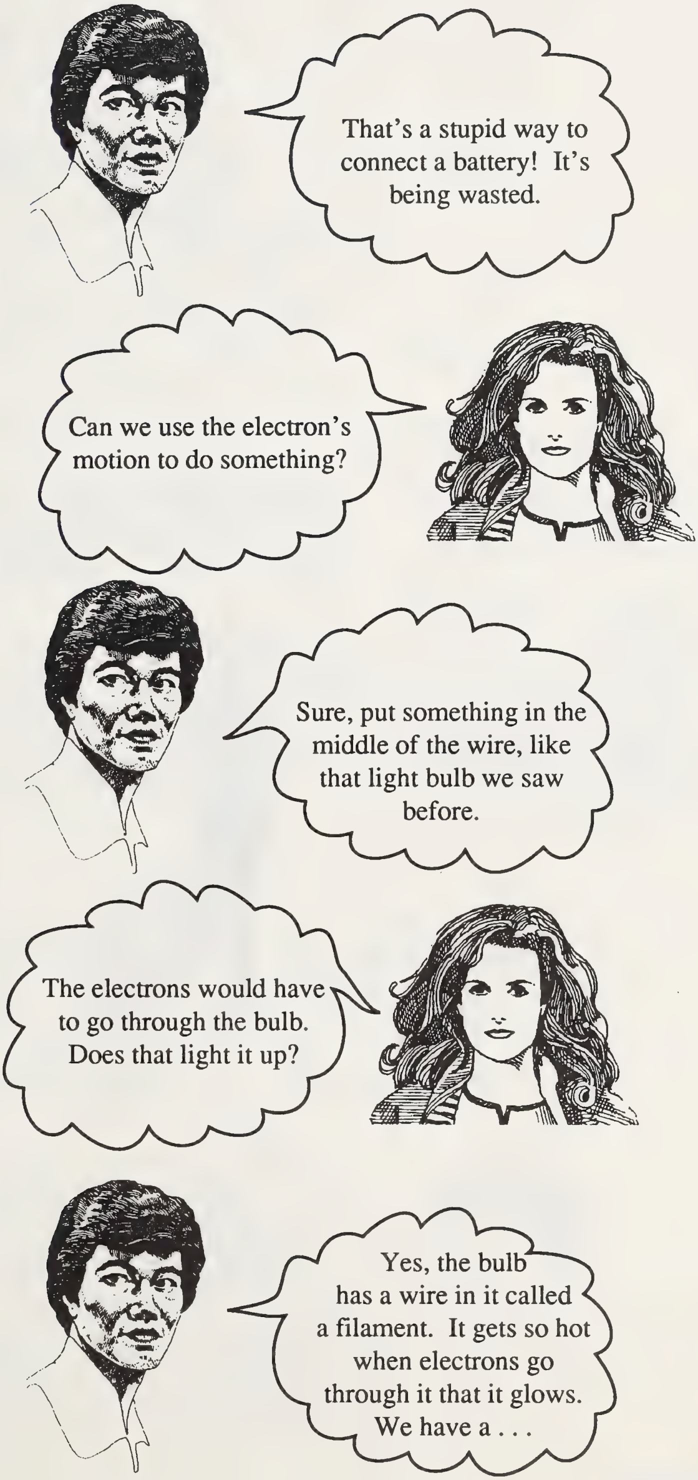


current - the rate at which electricity flows, measured in amperes

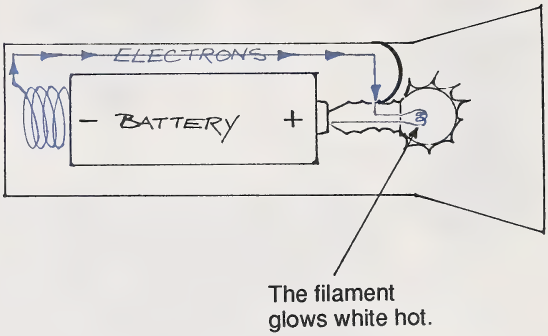
As the **current** flows, a chemical reaction takes place causing the battery to supply electrons to the negative terminal and to remove them from the positive terminal. The electrons continue flowing through the circuit as they move from where they are in excess to where they are in short supply.

While the current flows, the chemical reaction inside the battery causes certain substances to be consumed. In a carbon-zinc battery, for example, the zinc metal layer becomes thinner and thinner as the battery is used. The more the current has flowed, the more the key substances become used up. When the key substances are completely used up, the chemical reaction stops, the terminals become neutral, and the battery is dead.




That's a stupid way to connect a battery! It's being wasted.
Can we use the electron's motion to do something?
Sure, put something in the middle of the wire, like that light bulb we saw before.
The electrons would have to go through the bulb. Does that light it up?
Yes, the bulb has a wire in it called a filament. It gets so hot when electrons go through it that it glows. We have a . . .

Flashlight

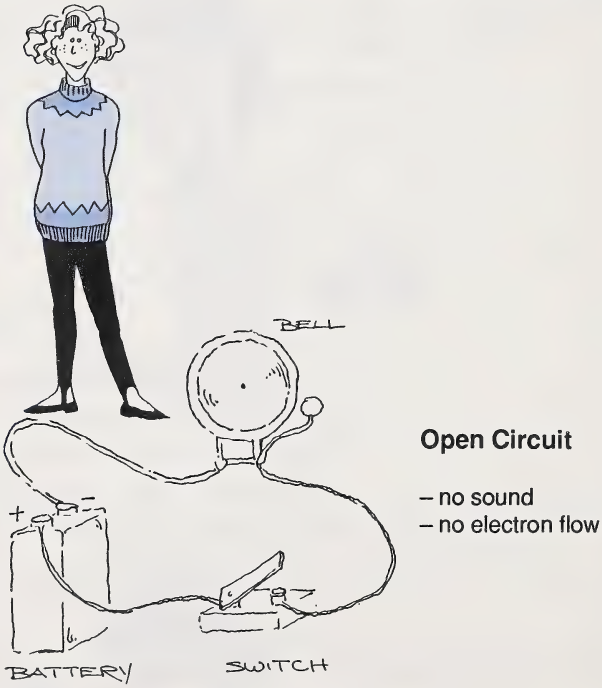


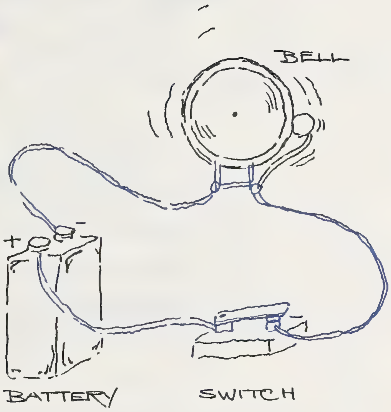
circuit - a loop of electricity, a path for electrons to follow

closed circuit - a complete circuit; turned on

open circuit - a circuit that has a break in it; turned off

A path for electrons is called a **circuit**. Electrons will flow only if they can go all the way. This is a **closed circuit**. A break in the circuit anywhere will stop the electrons. This is an **open circuit**. A switch opens and closes a circuit.





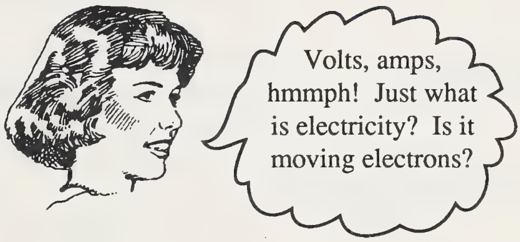
Closed Circuit

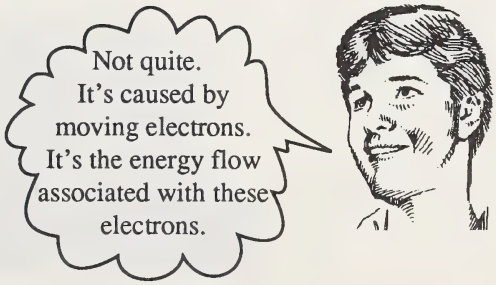
– bell rings
– electrons can flow

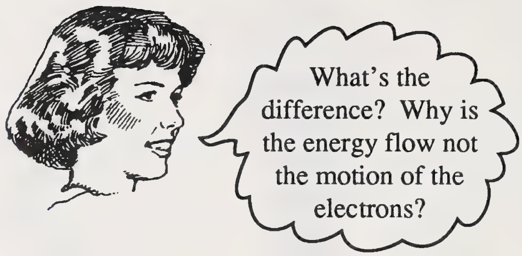
volts - units that measure the electric potential difference (energy difference between two parts of a circuit)

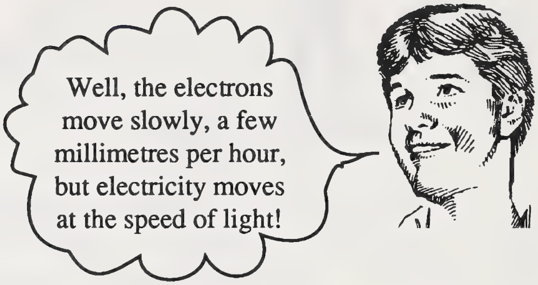
amperes - units that measure electric current, or the rate of flow of electrons

The following information should clear up the confusion that usually exists about volts and amps. The concentration of electrons at the negative end of the battery is the **voltage**. Volts measure the energy difference between the ends of the battery. When the circuit is closed, the amount of electricity flowing per second is the current in **amperes** (amps for short).









1. Look at a small battery. What is the voltage printed on it?

    ____

2. If a flashlight uses two batteries and you hook up five batteries to its bulb, predict what will the bulb do?

    ______________ Why? ______________

    ____

    ____

3. If a bulb burns out, is the circuit open or closed?

    __________ Why? ____________________

    ____

    ____

4. a. The energy difference in a circuit is the ______________.

    b. The rate of flow of electricity is the ______________.

Check your answers by turning to the Appendix, Section 2: Activity 2.

Do either Investigation A or B.

Investigation A: A Quick Flashlight

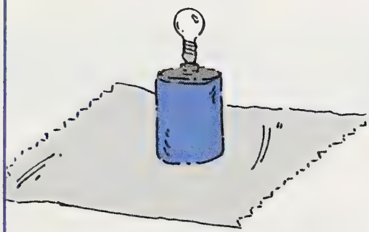
Materials You Need

- aluminum foil
- battery (Take these from a flashlight – you can put them back later.)
- bulb

Steps to Follow

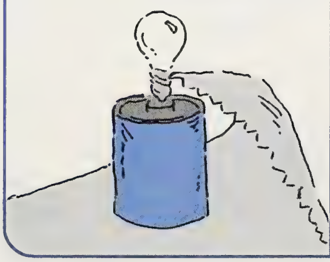
STEP A

Stand the battery on the foil. Hold the bulb on top of the battery.



STEP B

Touch a corner of the foil on the side of the bulb.



OBSERVATION

Did the bulb light?________________
How does electricity go through the bulb? (What path?)

____

____

____

Conclusion

Did you need a wire?

____

Why or why not?

____

____

Investigation B: Flashlight Parts

Take a flashlight apart and see if you can trace the circuit the electricity makes.

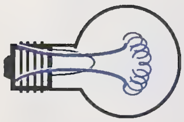
Check your answers by turning to the Appendix, Section 2: Activity 2.

Important Note: Unless you are an expert, do **not** experiment with household electrical current. It can kill you. Use batteries instead.

Activity 3: Some Electrical Devices

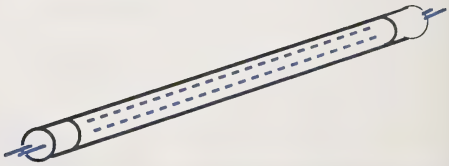
Look at these devices. Trace the path that electricity takes through them.

Incandescent Light



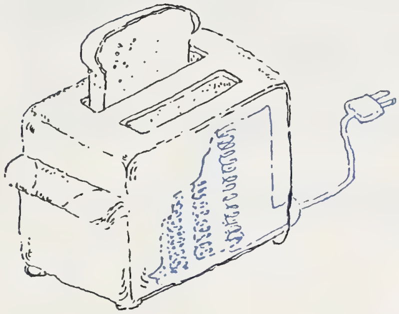
The filament heats up enough to glow.

Fluorescent Light



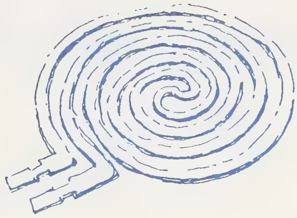
The electrons jump through the tube causing the gas inside to glow.

Toaster



The filament gets hot enough to glow a dull red. The heat then toasts the bread.

Electric stove



The element spirals in and out. It heats up when the current passes through. (An electric oven works the same way.)

1. What's the difference between how an electric stove and a toaster work?

___

___

___

The amount of current you use tells you how much energy you are using (and how much money you will be charged).

energy - ability to do work, measured in joules

joule - the standard unit of energy It is equal to one newton of force exerted over a distance of one metre.

power - the rate of doing work; the rate of energy use The standard unit of power is the watt.

watt - the standard unit of power One watt is one joule of energy per second.

Energy is measured in **joules**. A joule is a small amount of energy. Electrical **power** is measured in **watts**. A watt is one joule of energy per second. People use millions of joules of electrical energy in one day. For this reason, utility companies sell electrical energy in larger units – kilowatt hours (kW • h). One kW • h is a kilowatt (1000 watts) of power over a time period of one hour (3600 seconds). A kW • h is 3 600 000 joules of energy.

Study the following example:

How much would it cost to run a 1500 W heater for 8 hours if 1 kW • h of energy costs 7¢?

The power is $1500\ \text{W} = 1500\ \text{W} \times \dfrac{1\ \text{kW}}{1000\ \text{W}} = 1.5\ \text{kW}$.

The electrical energy is $1.5\ \text{kW} \times 8\ \text{h} = 12\ \text{kW}\bullet\text{h}$.

The cost is $12\ \text{kW}\bullet\text{h} \times \dfrac{7¢}{1\ \text{kW}\bullet\text{h}} = 84¢$.

It costs 84¢ to run the heater for 8 hours.

2. a. If 1 kW • h of energy costs 5.5¢, and you use 6 kW of power for 3 hours, how much will that cost?

____

____

____

b. If you leave a 100 W light bulb on for 3 hours, how much will that cost?

____

____

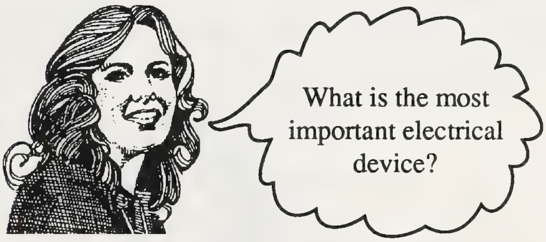
____

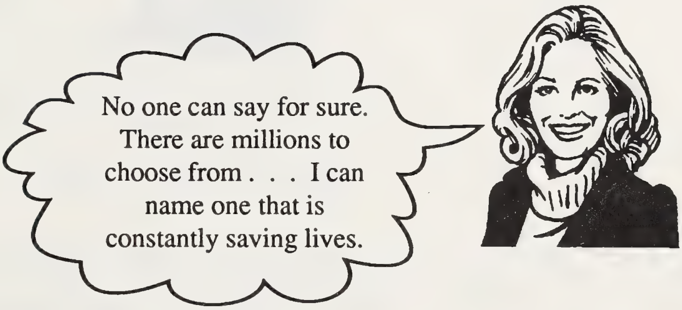
Check your answer by turning to the Appendix, Section 2: Activity 3.

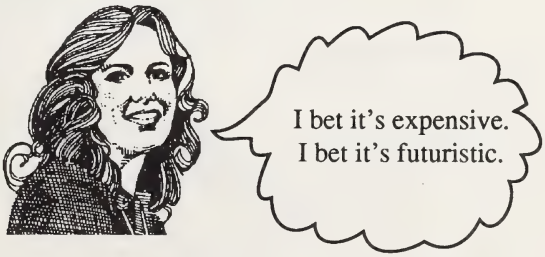
VOLTS × AMPS = WATTS

This is always true. Household current is always at 120 volts. The utility company makes sure of that. If 15 amps go through a circuit in your house, the power consumption is:

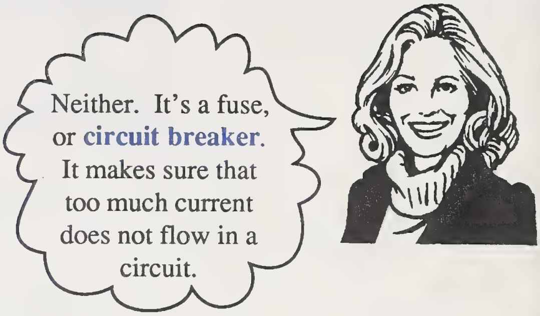
$$\text{volts} \times \text{amps} = \text{watts}$$
$$120 \times 15 = 1800 \text{ watts (or 1.8 kW)}$$

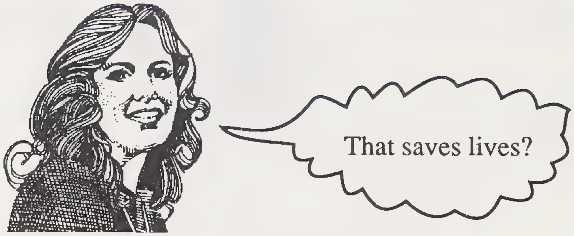


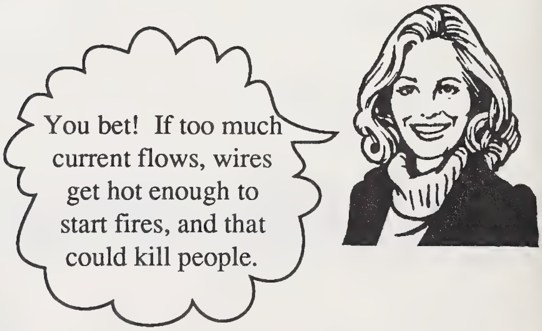




circuit breaker - a device that breaks a circuit if too much electricity flows

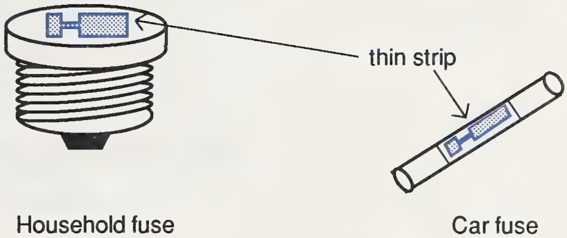






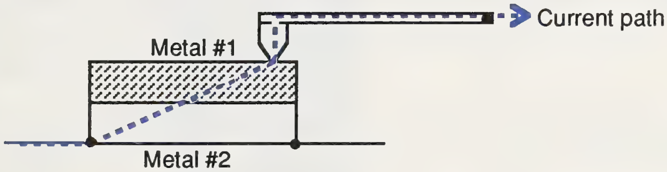
fuse - a circuit breaker that uses the heat from a current to melt a metal strip to break the circuit

Fuse



The thin strip in the fuse melts when a certain number of amps (current) pass through it. The circuit breaks. Fuses are rated in amps. A rating of 15 amps means that no more than 15 amps of current can pass through the circuit. More than 15 amps of current would cause the fuse to melt. You should replace a fuse with an equally rated fuse.

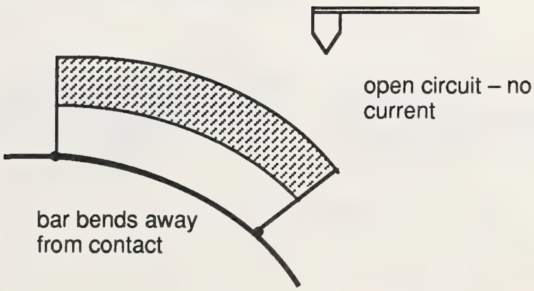
Circuit Breaker



bi-metallic strip or compound bar

The two metals expand at different rates. Electricity heats them both and the bar bends. If too much current passes, the bar bends until it breaks contact with the rest of the circuit. After a few minutes the metals will cool, then the circuit breakers can be reset.

Too much current . . .



3. Electrical appliances have a message plate on them that tell you how much electricity they use. Read the plates of three of the following appliances. Fill in the chart for the ones you choose. Remember:

$$\text{volts} \times \text{amps} = \text{watts}$$

Note: Unplug any appliance that you are going to turn upside down!

Appliance	Volts	Amps	Watts
toaster			
electric kettle			
stereo component			
60W light bulb			
electric heater			
electric drill			
radio (plug in type)			
circular saw			

A household circuit is usually 15 amps. This means that you can't plug in more than 15 amps (or 1800 watts) of appliances on any single circuit.

4. Will the breaker (fuse) blow if you plug the following appliances into one circuit?

   150 W bulb
   650 W car heater
   900 W toaster

   ___

   ___

   ___

Check your answers by turning to the Appendix, Section 2: Activity 3.

Activity 4: Magnets

lodestone - naturally occurring magnet (iron mineral)

A long time ago, people discovered that a type of iron-bearing rock had the ability to attract other pieces of iron. The mineral is called **lodestone** and you can still get samples of this mineral today.

If you take two of these rocks, you would find that by turning them around, you could make them attract or repel each other. They have a north and a south pole.

Opposite Poles Attract

Like Poles Repel

Investigation: Building a Compass

People also learned a long time ago that the Earth itself acts like a magnet. If you suspend a magnet, or let it float, it will line up with the north and south magnetic poles of the Earth. Such a device is called a compass. Here's how to make yourself a compass. Make it, unless you have access to a manufactured compass.

Materials You Need

- sewing needle
- glass of water
- wax, wood, cork (something non-metallic that floats)

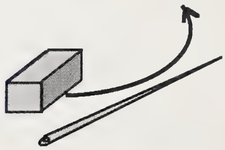
Steps to Follow

STEP A

First you have to find a magnet. Look for a fridge magnet, can opener, old speaker, or the door of the fridge may have magnetic strips around it.

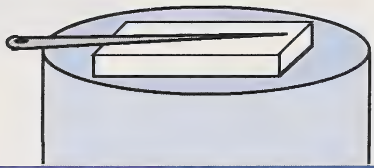
STEP B

Stroke the needle ten or twenty times with the magnet (or stroke the magnet with the needle if you can't move the magnet). Always stroke in the same direction.



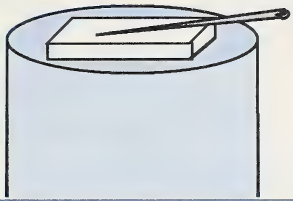
STEP C

Stick the needle into the non-metallic object so that it's nearly horizontal. If you have problems with this you can float the needle by itself. Make sure the needle is dry. Carefully place the needle on the water so that you don't break the surface of the water with your fingers or the needle. If the needle sinks, dry it well and try again. You can actually drop the needle 1 mm or 2 mm, but make sure it hits the surface of the water flat.



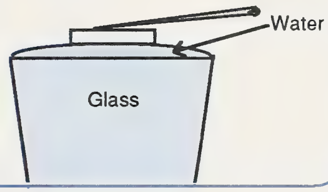
STEP D

Fill the glass full with water, and float the object.



STEP E

If the object sticks to one side of the glass, add water until the glass is very full. The object will then float to the middle.



Observations

1. a. Does the needle point to geographical north? (Streets run north-south; your house is probably built in a north-south orientation.)

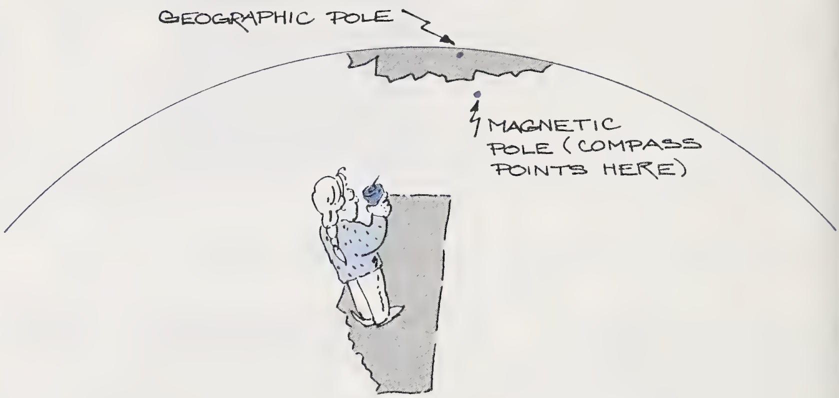
   ___

   b. Is it off from geographical north to south a bit?

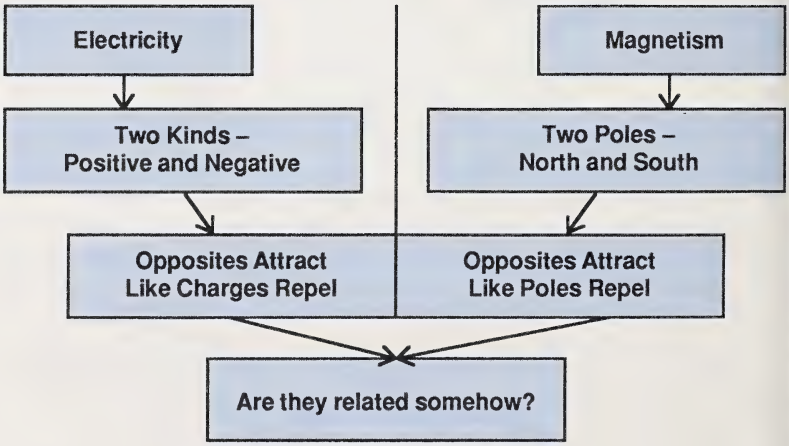
   ___

Conclusion

Your needle should have pointed slightly to the east of north. This is because the north magnetic pole and the north geographic pole of the Earth aren't in the same place.



Two Different Things . . .



electromagnetism - magnetism produced by an electric current

Investigation: Electromagnetism

Materials You Need

- compass (either your own or a manufactured one)
- battery (Use an AA size battery or smaller is possible. A D-cell battery heats the aluminum quite fast.)
- aluminum foil

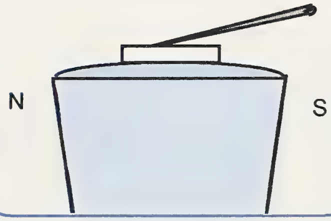
Steps to Follow

STEP A

Take a 1 cm wide piece of foil and fold it lengthwise. This is your wire.

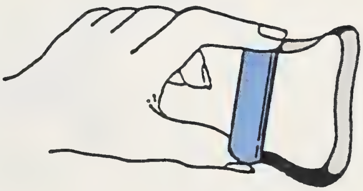
STEP B

Set your compass in position. Wait until it points north to south.



STEP C

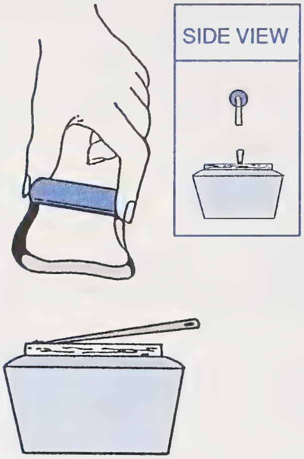
Place the wire on each terminal of the battery. Electricity is now flowing. The foil will warm up in about 5 to 10 seconds, so work quickly.



Caution: If the foil gets **hot**, break the contact and allow the foil to cool. Then proceed.

STEP D

Hold the foil parallel to the compass needle. Observe what happens when the foil comes close to the needle.



OBSERVATION

2. What did the compass needle do here?

____

____

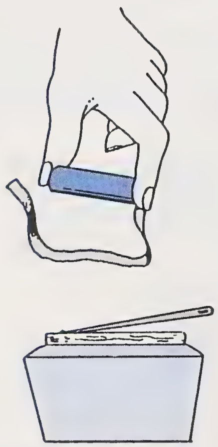
____

____

____

STEP E

Break the contact with the battery while keeping the foil close. Record what happens.



OBSERVATION

3. What did the compass needle do here?

____

____

____

____

____

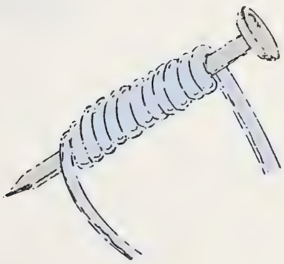
STEP F	OBSERVATION
Re-connect the foil. What happens?	4. What did the compass needle do here? ______ ______ ______ ______ ______

Check your answers by turning to the Appendix, Section 2: Activity 4.

Conclusion

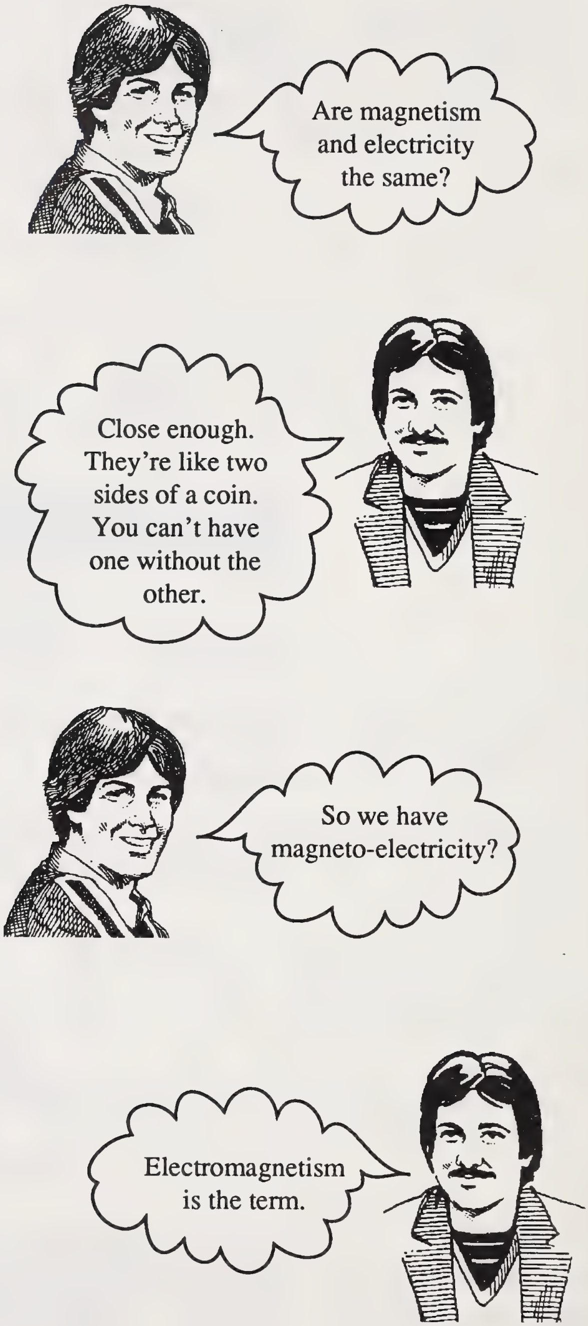
A current in a wire can affect a compass, which is a magnet. This means that a current in a wire has a magnetic field of its own. (Aluminum is **not** a magnetic metal either.)

If you can get some insulated wire, try wrapping several turns of the wire around a nail as shown.



Attach it to a battery, and put the end of the nail into a pile of lightweight iron things (tacks, individual staples, filings from a steel object). The nail has become an **electromagnet** and should pick up a few things. You can increase its strength by using more turns of wire, more batteries, or a larger battery.

electromagnet - an iron core that becomes magnetic when a current travels around it


Are magnetism and electricity the same?
Close enough. They're like two sides of a coin. You can't have one without the other.
So we have magneto-electricity?
Electromagnetism is the term.

5. What similarities do magnetism and electricity have? (Name two.)

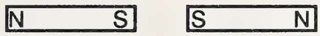
____

____

____

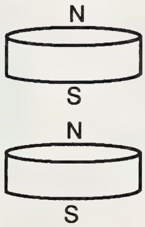
6. What would the magnets do in each of the following cases (attract or repel)

a.



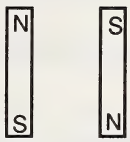
____

b.



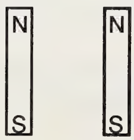
____

c.



____

d.



____

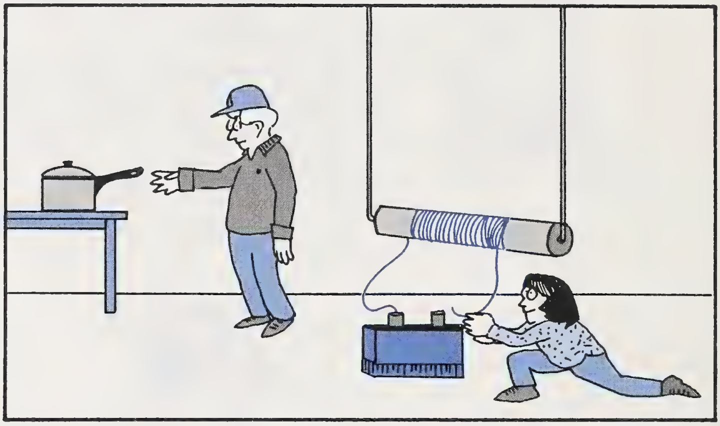
7. Think of a use for an electromagnet. Remember: You can turn off the magnetism by turning off the electricity.

____

____

____

Check your answer by turning to the Appendix, Section 2: Activity 4.



Activity 5: The Electromagnetic Devices

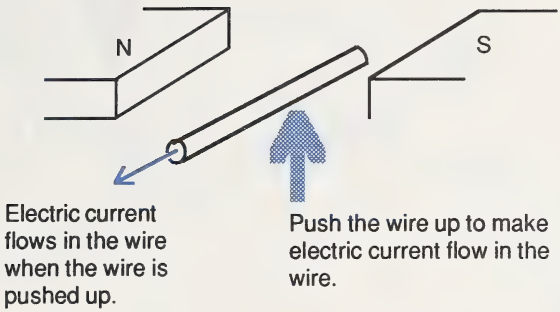
Many of the electrical devices that you use depend on two principles for their operation.

Generator Effect – A magnet moving past a wire (or a wire moving past a magnet) will cause an electric current to flow in the wire.

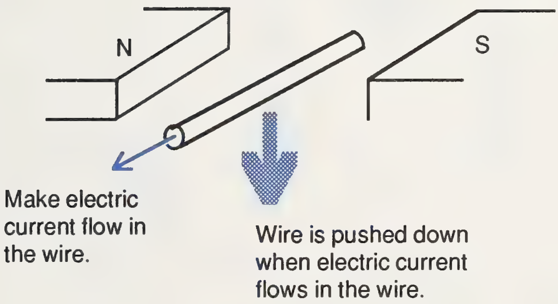
Motor Effect – Electric current flowing in a wire that is near a magnet will cause the magnet (or wire) to move.

These effects are hard to understand until you explore the theory of why they occur. It's almost magic to see them work, but they do!

Generator Effect



Motor Effect

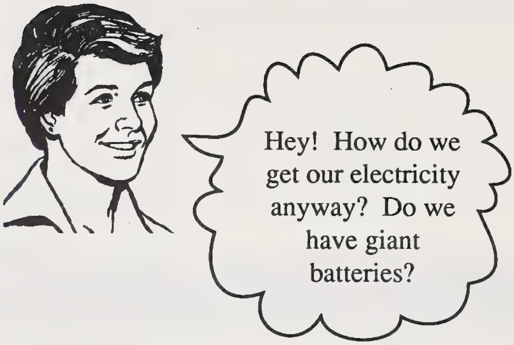


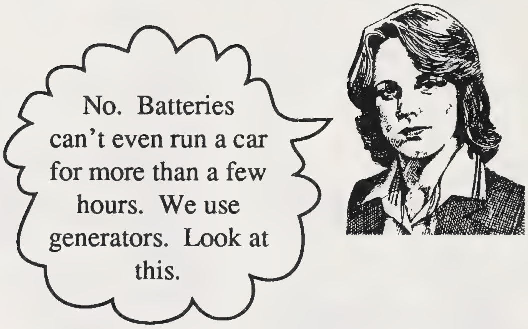
generator - a device that converts mechanical motion into electricity

motor - a device that converts electrical energy into mechanical motion

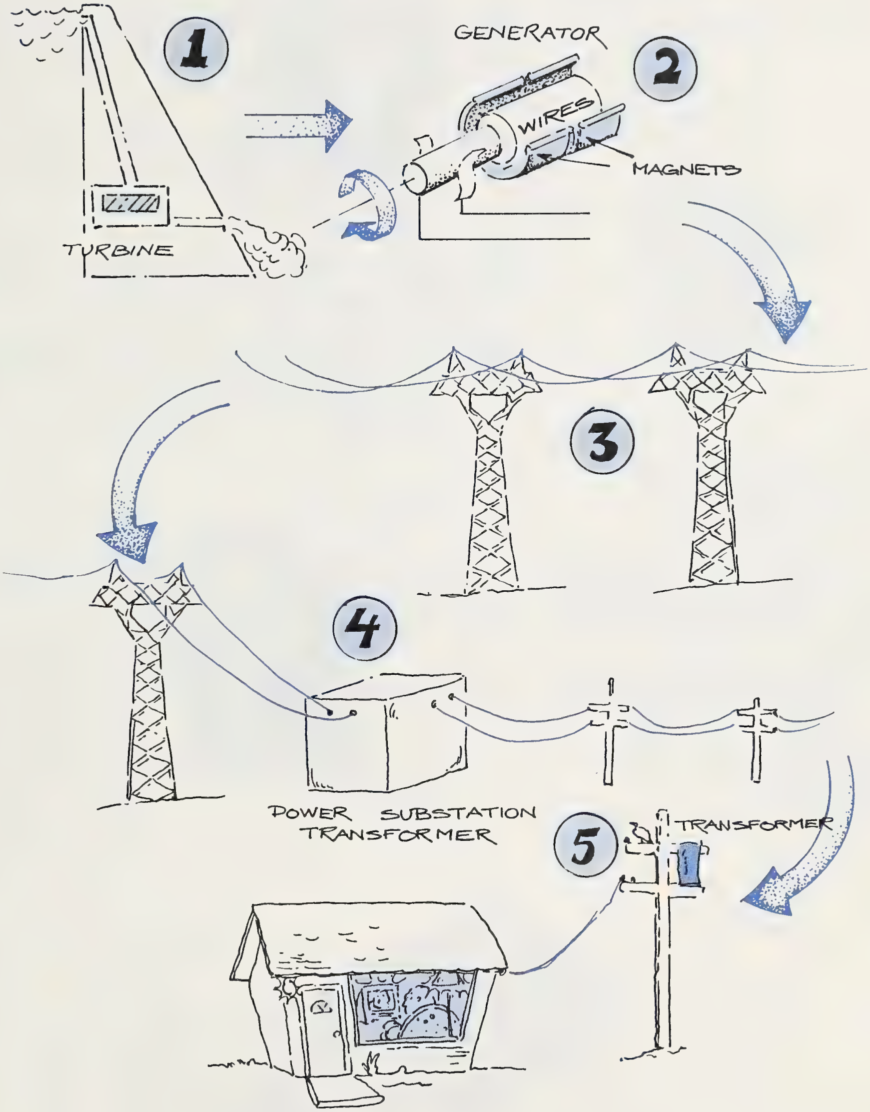
The two devices are – you guessed it – a **motor** and a **generator**.

It's hard to build a homemade generator that makes enough electricity to do some work. You **can** make a homemade motor if you can get thin insulated wire. The instructions for making a motor are at the end of this section.

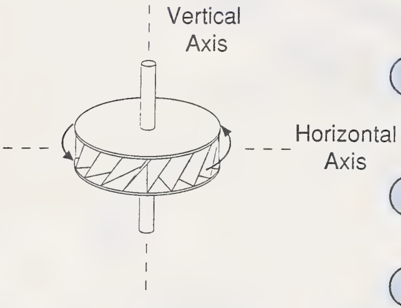

Hey! How do we get our electricity anyway? Do we have giant batteries?


No. Batteries can't even run a car for more than a few hours. We use generators. Look at this.

Hydroelectric Power



turbine - a wheel that spins rapidly on a vertical axis, powered by water or steam



1. Falling water hits a **turbine** and spins it (a turbine is a horizontal water wheel).

2. The turbine is connected to a generator which produces **A.C.** current. This means that the electrons move back and forth many times per second.

3. The A.C. current is carried from the dam to cities and towns hundreds of kilometres away by high voltage power lines (240 000V - 500 000V).

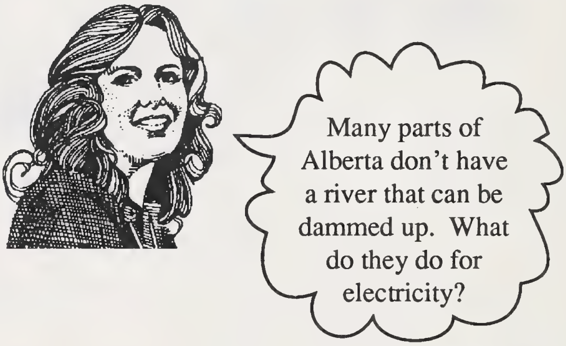
4. The current goes to power substations where it is stepped down, using **transformers**, to 79 000 volts and then to 13 800 volts.

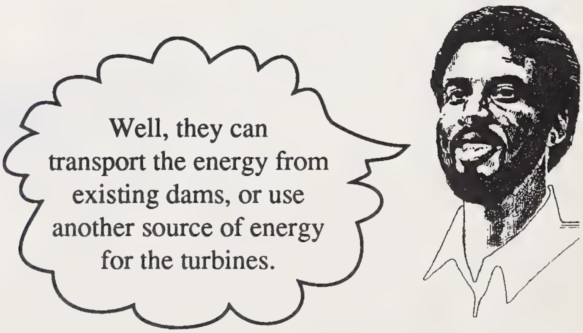
5. The current goes through neighbourhoods where it reaches another transformer on a pole (or underground). The voltage is stepped down to 120 volts, and then it enters your house.

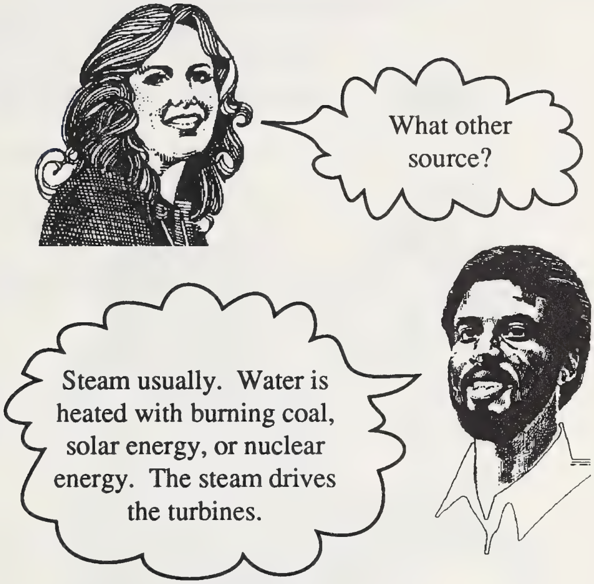
A.C. (Alternating current) - current that reverses its direction many times per second

D.C. (Direct current) - current that flows in one direction (batteries produce D.C. electricity)

transformer - a device that changes the voltage of an A.C. electric current





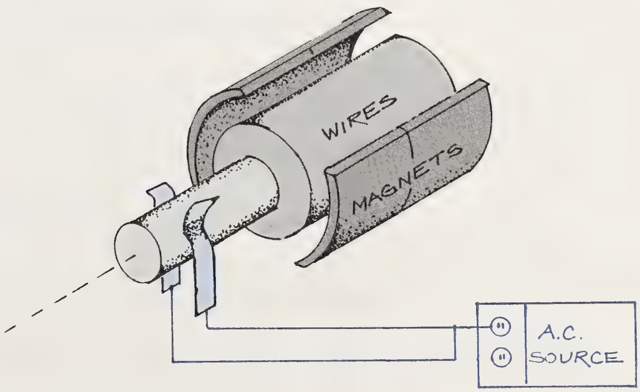


The Brazeau Dam, southwest of Lodgepole, is the largest hydroelectric station in Alberta. There is also a handful of small hydroelectric dams. Some hydroelectric power is purchased from British Columbia.

There are coal-powered stations located at Lake Wabamun and Genesee.

The Electric Motor

Look at the diagram of a generator.



Take the **same device**, but instead of using a turbine to spin it to make electricity (A.C. remember), attach it to a **source** of A.C. electricity (plug it in). The device will turn, and you will have a motor. The difference between a generator and a motor is how you use them.

1. Move a wire past a magnet. You will get an

   ________________ ________________.

2. Put electricity through a wire near a magnet. The wire will

   ________________ .

3. **Electricity** ⟶ **Movement**

   Device

   ____

4. **Movement** ⟶ **Electricity**

   Device

   ____

5. If you needed to make electricity and all you had was an old motor, how would you do it?

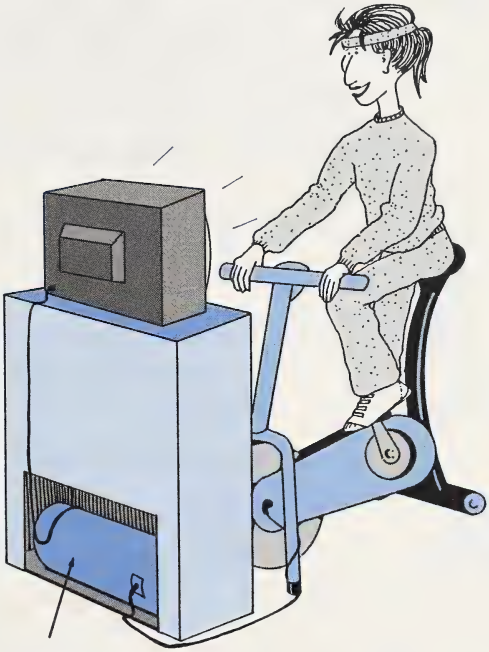
   ____

   ____

   ____

   ____

"Exercise and Watch TV!"



Check your answers by turning to the Appendix, Section 2: Activity 5.

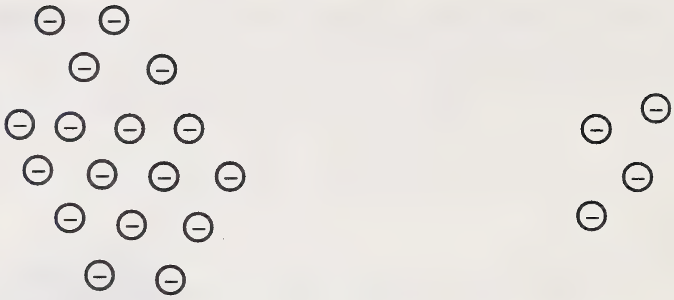
Follow-up Activities

If you had difficulties understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

Electrons are all around you. They can move around. Too many electrons in one place results in a **negative charge**.

Not enough electrons in one place results in a **positive charge**.



– Charge + Charge

Electrons will equal out their numbers if they can. A **static spark** is caused by electrons equaling out their distribution. **Conductors** allow electrons to move, **insulators** don't.

1. Complete this chart.

things that give us electricity	a.
b.	negative charge
too few electrons around	c.
two negative charges close will	d.
e.	conductor
won't allow electrons to move	f.

2. Give two examples of insulators: ______________________,

   and ______________________.

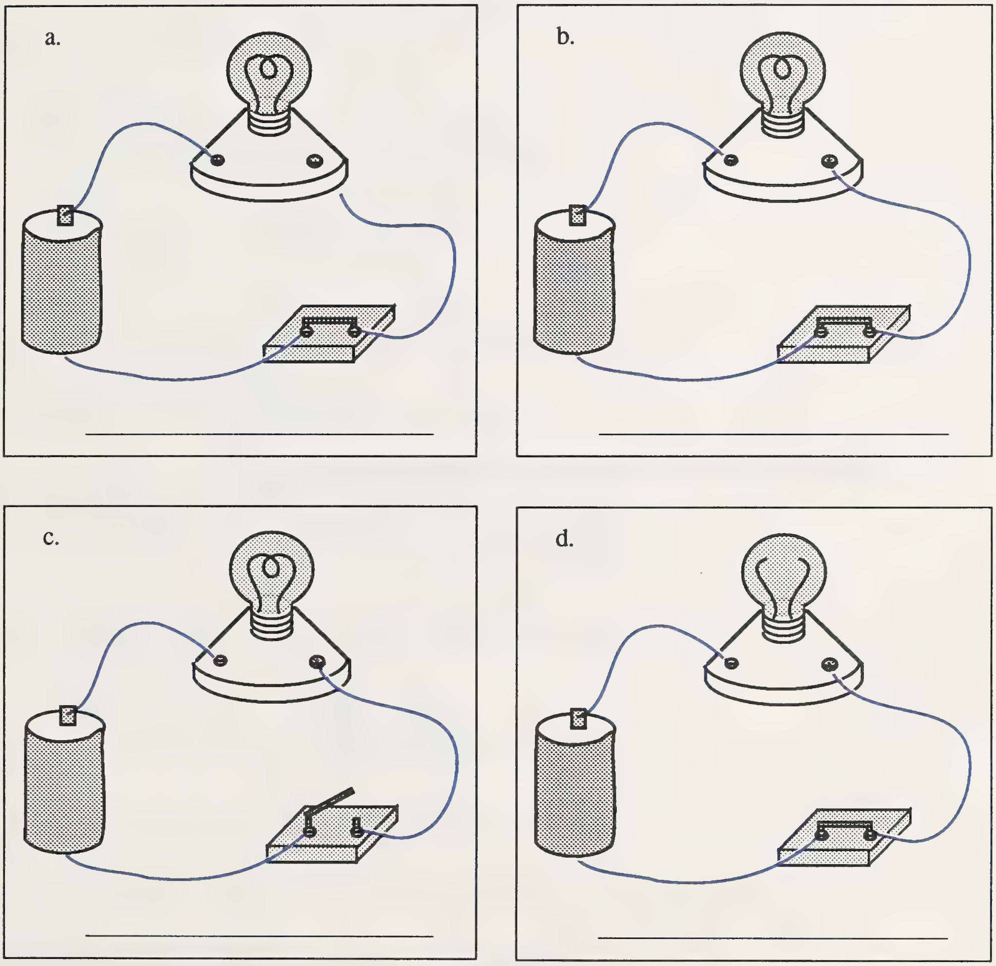
3. Give two examples of conductors: ______________________,

   and ______________________.

A path that electrons follow is a **circuit**. A **battery** produces electricity chemically. A complete circuit is **closed**. A broken circuit is **open**. Electrical energy is measured in **volts**. The amount of current flowing is measured in **amps**. Power is measured in **watts**.

Volts × Amps = Watts

4. Will the light go on in each of these circuits?



5. If a drill uses 4 amps of current, how many watts is it using? (Remember there are 120 V in a house.)

____

____

6. A soldering iron has a rating of 80 W. How many amps does it use?

____

____

7. An electric heater has a rating of 1500 W. If you leave it on all night (8 hours), how many kW•h did you use?

____

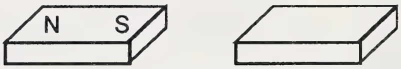
____

8. Electric currents produce heat. Name three devices that use this idea.

______________, ______________, and ______________.

Magnets are things that attract some metals. (Iron is the most common metal that magnets attract.) A magnet has a **north and south pole**. **Opposite** poles **attract**, **like** poles **repel**. Electric currents have magnetic fields.

9. These magnets attract. Label the poles of the second magnet.



10. What device shows that electric currents have magnetic fields?

____

11. What name is used to show that magnetism and electricity are two parts of one thing?

____

12. Electromagnetism is based on two phenomena. Fill in the following chart.

Generator Effect	Motor Effect
A moving __________ in a ________________ produces __________.	Running __________ through a wire near a ____________ makes the wire __________.
A generator turns __________ into ________________.	A motor turns __________ into ________________.

Enrichment

1. Pure water is an insulator. Why is it said that water and electricity don't mix?

____

____

____

____

2. Check one circuit in your home and find out how many amps are on it.

____

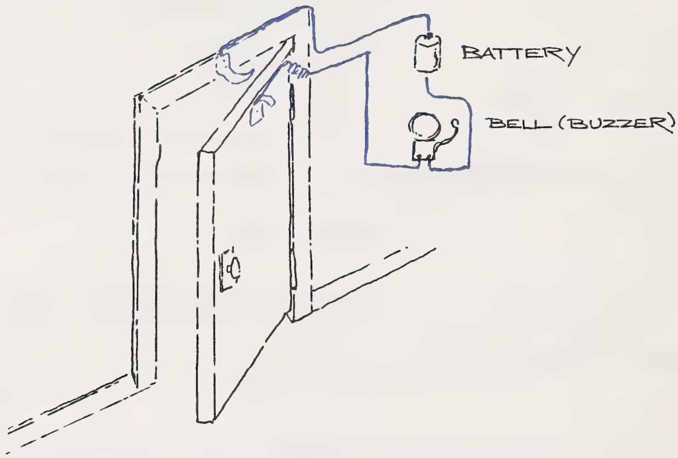
____

3. Build a burglar alarm for your room (or any room). Here are some instructions. (Be sure and get permission before pounding nails into the door frame.)

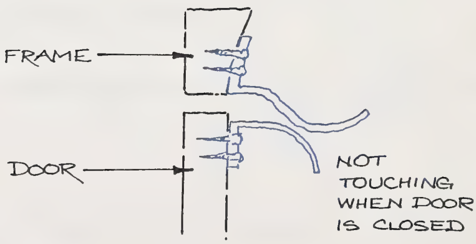
Materials You Need

- thin metal strips
- wire (insulated)
- battery
- screws
- buzzer or bell

Connect the circuit as shown.



detail of clips on door and frame



When the door opens, the clips touch and close the circuit, causing the bell to ring.

4. Make a homemade electric motor. Here are some plans for you.

Materials You Need

- 60 cm copper insulated wire (#22 to #30)
- two paper clips
- one or two magnets (any type)
- one battery (6 V if possible)
- electrical tape
- two connecting wires

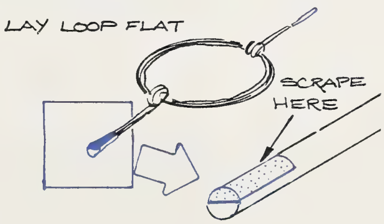
Steps to Follow

STEP A

Make a coil by wrapping the wire around a circular object. Loop the ends and flatten.

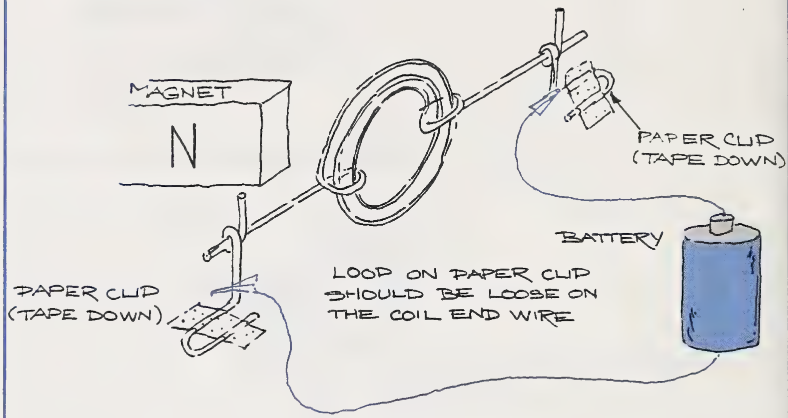
STEP B

Scrape the insulation off half of the ends of the coil.



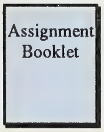
STEP C

Assemble the parts as in the diagram. Give it a push to start it. It should keep spinning.



Conclusion

In this section you learned about two phenomena that are closely related – electricity and magnetism. You watched static electricity in action and current electricity in operation. You saw how the two phenomena can produce the generator and motor effects. In all stages you related these things to devices that use their principles.



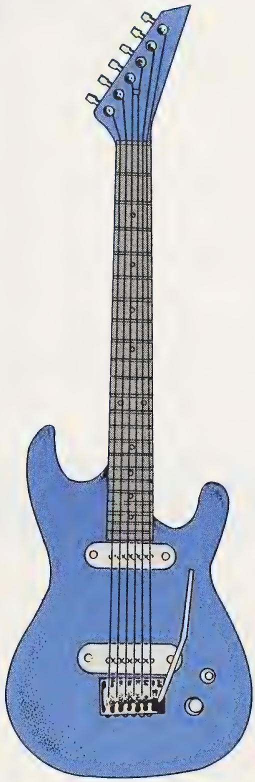
ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 2.

Section

3

Complex Technology - A Case Study



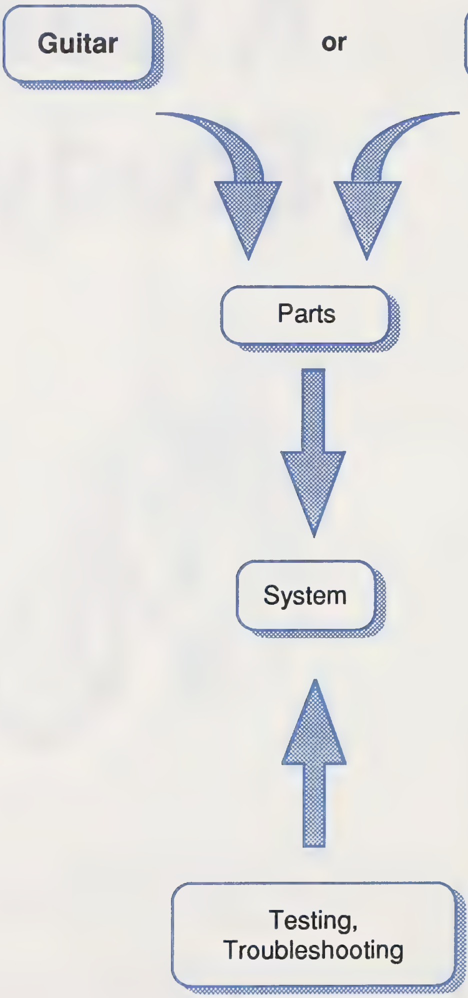
Do you like riding a bicycle? Do you race? How many of your gears do you use? Do you listen to music, or do you like to play music? Have you ever wondered how your stereo works?

This section will present two case studies for you. One case study will be looking at a derailleur-type bicycle, and the other will be looking at an electric guitar.

You must do **one** of the studies. You may do both if you have the time or the interest.

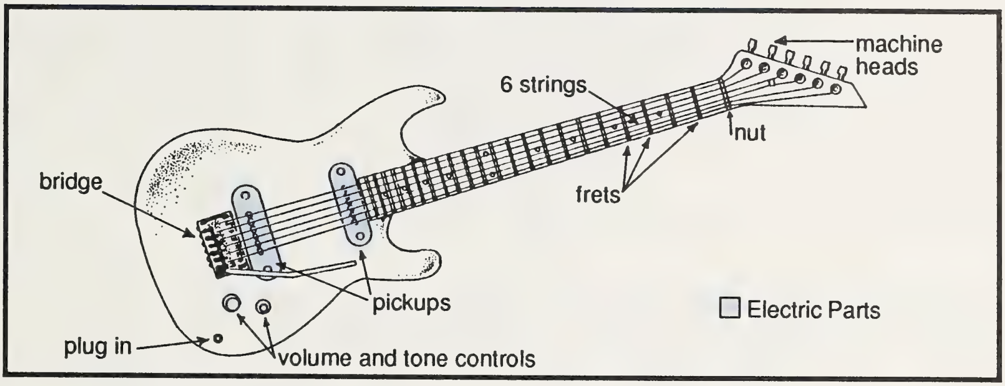
Look at this diagram. It will help you understand the organization of this section.

Note: If you choose the electric guitar, do Activities 1, 2, and 3. If you choose the bicycle, do Activities 4, 5, and 6.



Activity 1: The Guitar Itself

THE GUITAR

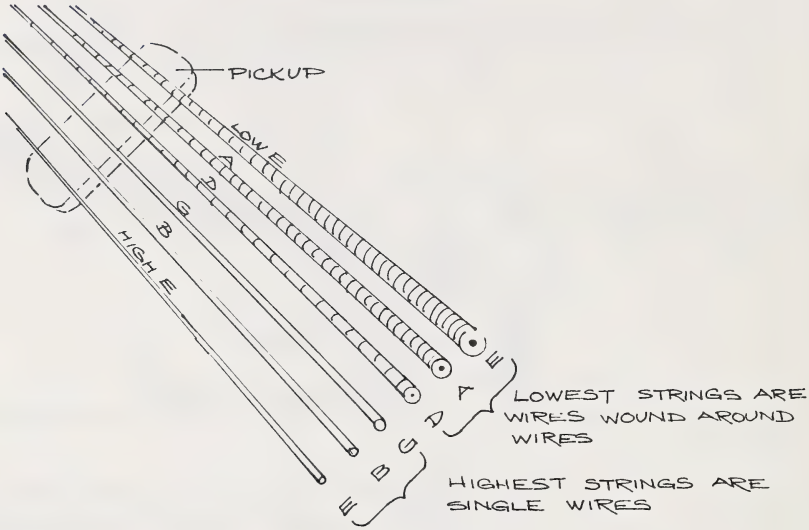


A guitar uses vibrating strings to make its sound. (You learned this in Module 1, Section 3, Activity 6.) Here is what scientists have learned about strings.

	How Pitch Changes Low ⟷ High	
	Low	**High**
Law of Length	long	short
Law of Tension	loose	tight
Law of Thickness (or mass)	thick or heavy	thin or light

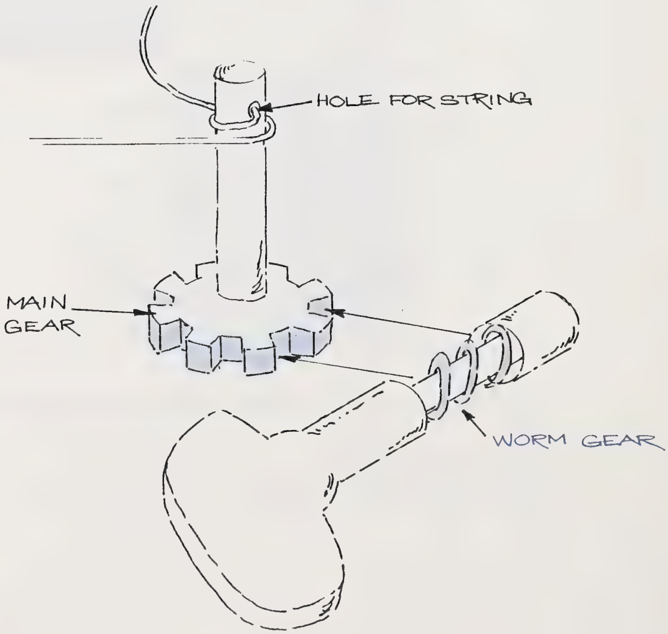
These are the three **laws of stretched strings**.

Look at this close-up view of the guitar strings. Look at a cross section of them.



Now look at the machine heads (tuners).

worm gear - a screw thread that meshes with a regular gear



1. a. What can you say about the lengths of the strings?

   ____

   ____

   b. What can you say about the thickness of the strings?

   ____

   ____

   ____

2. The tuning pegs, or machine heads, adjust the strings by tightening or loosening them. Describe two ways in which simple machines are used to give you a great mechanical advantage in doing this.

   - ____

     ____

     ____

   - ____

     ____

     ____

3. Which of the laws of stretched strings have been used to tune the guitar?

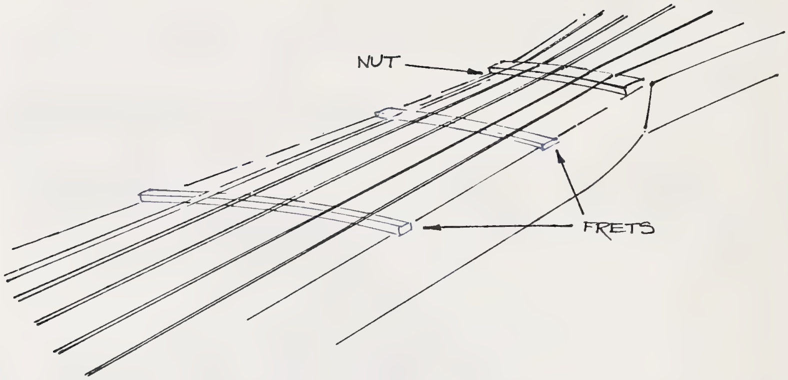
   ____

   ____

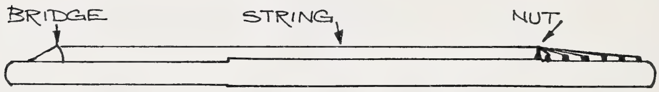
   ____

Check your answers by turning to the Appendix, Section 3: Activity 1.

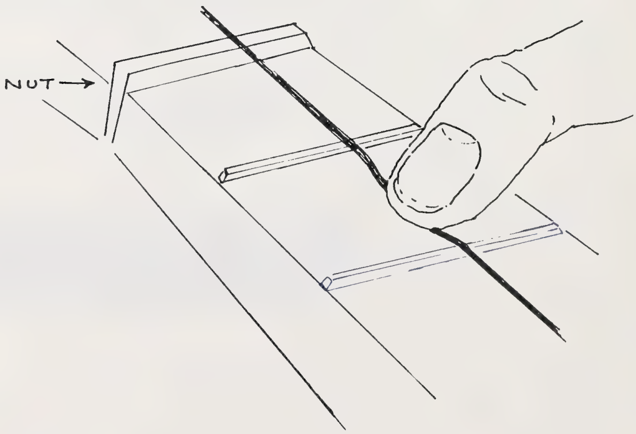
Now look at the frets.



How long is a string?



A string is as long as the part that vibrates. It's the distance from the nut to the bridge, if no fret is touched by the player. Look at this player's finger.



4. a. What does pressing your finger behind a fret do to the string?

____

____

____

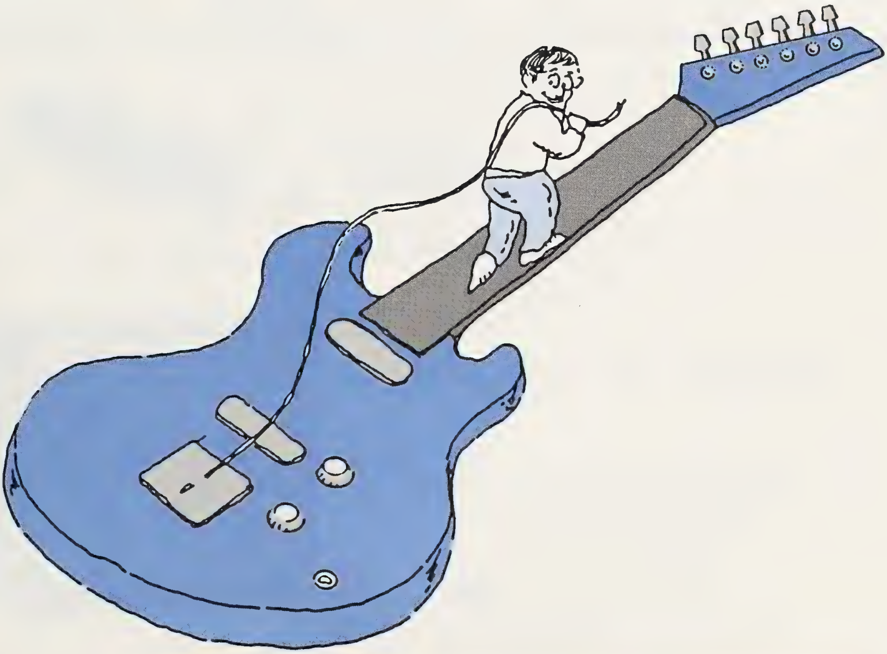
b. What effect will this have on the pitch of the note?

____

c. Which law of stretched strings does this use?

____

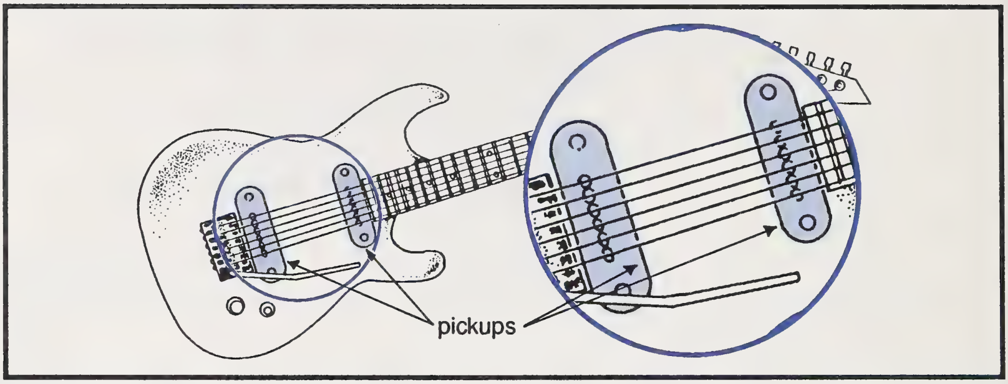
____

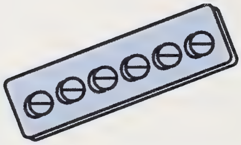


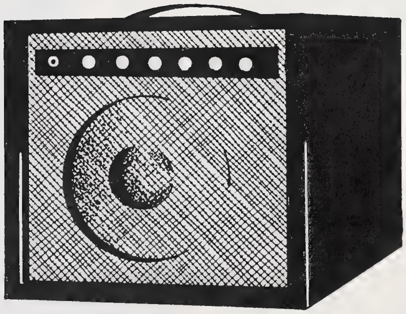
Check your answers by turning to the Appendix, Section 3: Activity 1.

Activity 2: Amplifying the Sound

An electric guitar makes a very soft sound by itself. It doesn't have the hollow body and vibrating top to amplify the sound like an acoustic guitar. It must turn the string vibration into an electrical signal and amplify the signal electronically.





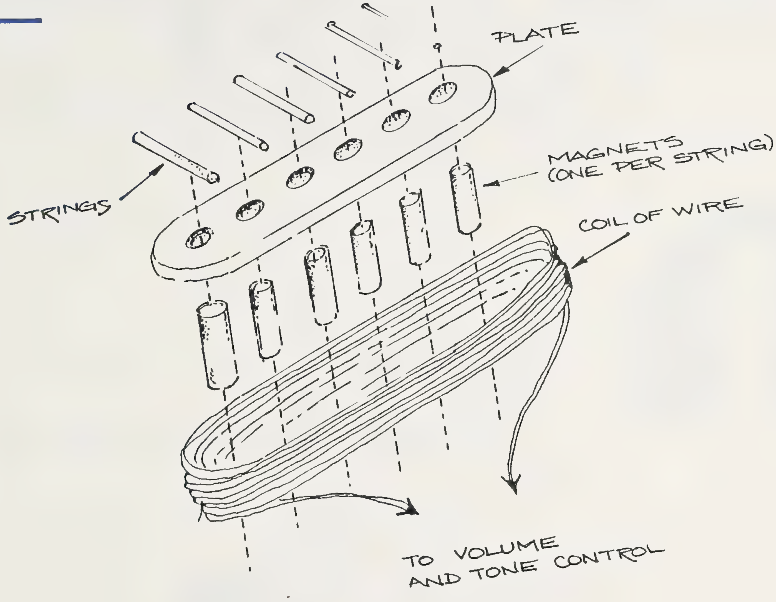


An electric guitar is very quiet without an amplifier.

In Section 2 of this module you learned about the generator and motor effects. (Both are a result of the interaction of electricity and magnetism.) Now you will see how powerful a scientific principle can be!

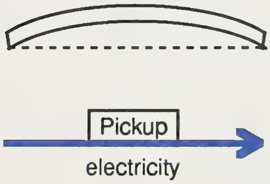
pickup - a device that turns string vibrations into an electric signal

The **Pickup** (exploded view)

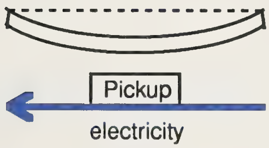


This is how it works.

- Strings vibrate in a magnetic field.
- This generates an electric current.
- The current is in step with the string's vibration. (So it's coded sound!)



string vibrates up – sends electricity one way



string vibrates down – sends electricity the other way

transistor - a solid state device that varies the flow of electricity through it

This is a weak electrical signal. The amplifier uses a number of **transistors** and a household current to multiply this weak signal many times. It can change the tone of the sound as well. A strong signal in step with the weak guitar signal is the result.

1. Can electric guitar strings be made of nylon? ____________________

   Why or why not? ______________________________________

   ____

   ____

   ____

   ____

2. If you only had an electric guitar and an amplifier, could you hear yourself play? ______________________________________

   Why or why not? ______________________________________

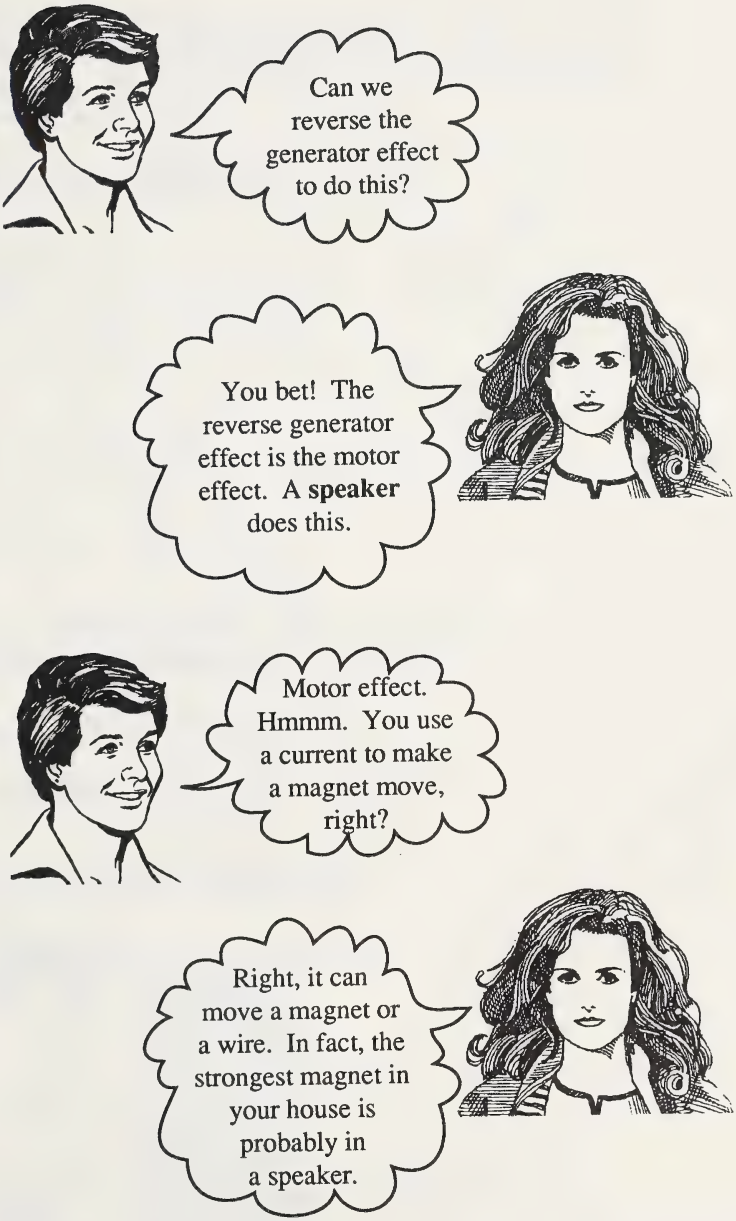
   ____

   ____

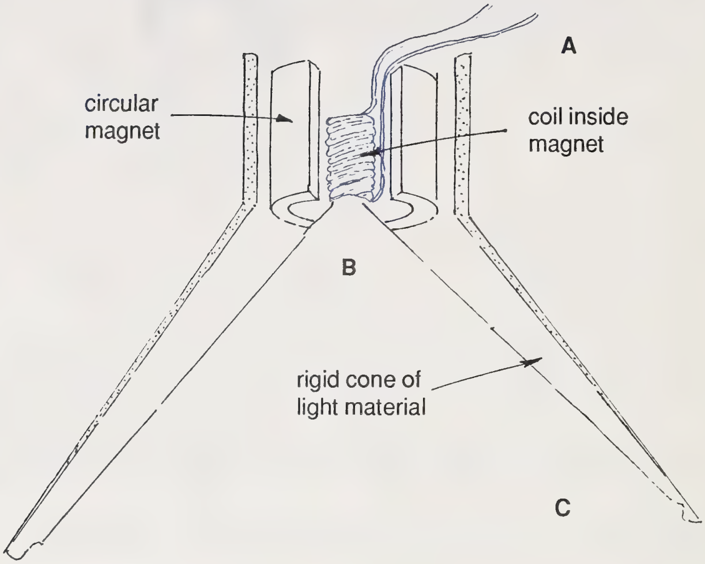
   ____

Check your answers by turning to the Appendix, Section 3: Activity 2.

You can't hear electricity; therefore, the signal must be converted back into sound waves.


Can we reverse the generator effect to do this?
You bet! The reverse generator effect is the motor effect. A **speaker** does this.
Motor effect. Hmmm. You use a current to make a magnet move, right?
Right, it can move a magnet or a wire. In fact, the strongest magnet in your house is probably in a speaker.

A Speaker



A. A signal from the amplifier causes the motor effect.

B. The magnet is mounted firmly so that the coil moves.

C. The cone attached to the coil sets up a sound wave in the air.

Activity 3: The Whole System

How often have you been at a concert where the sound system either delayed or ruined the concert? A concert band uses far more equipment than is shown here. The ability to troubleshoot a sound system is as important to a concert as the music itself.

1. Label the part shown and explain its function.

   A: ______________________________

   ____

   B: ______________________________

   ____

   C: ______________________________

   ____

2. Suppose that you are the sound person for this performer. The following problems occur. Suggest ways to fix each problem.

   a. There is no sound from **one** speaker.

   ____

   ____

   ____

   b. There is no sound from **either** speaker.

   ____

   ____

   ____

   c. There is intermittent sound from **both** speakers.

   ____

   ____

   ____

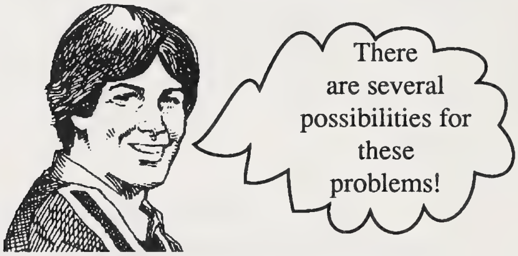
d. As the sound person, what extra equipment would you have for this performer?

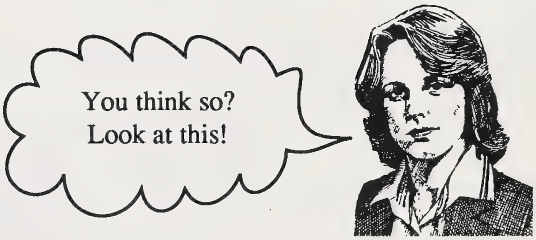
____

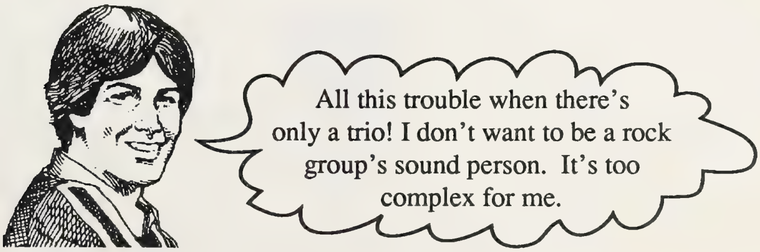
____

____

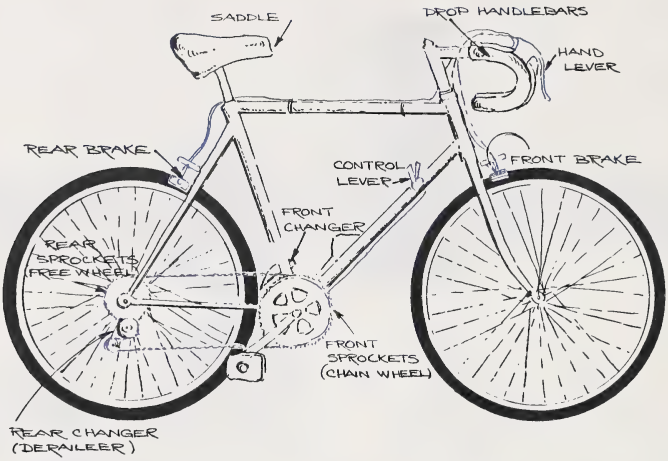
Check your answers by turning to the Appendix, Section 3: Activity 3.






All this trouble when there's only a trio! I don't want to be a rock group's sound person. It's too complex for me.

Activity 4: The Bicycle (Gears)



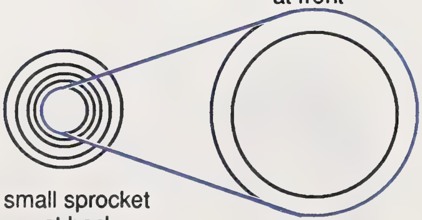
As a mode of transportation, the bicycle is the **most** efficient. As a vehicle it must start, get you where you're going, and stop when you get there.

A bike has two sets of sprockets (gears). The front set is the **chainwheel** and the rear set is the **freewheel**. A ten-speed bike has five gears on the freewheel and two on the chainwheel. An eighteen-speed bike has three gears on the chain wheel and six on the freewheel.

Gear changing is done with front and rear control levers and front and rear gear changers (**derailleurs**).

derailleur - a gear-changing system that moves the chain from one gear to another

Highest Gear

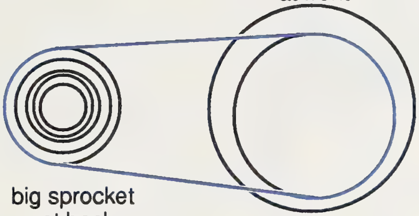


– hardest to pedal

– lowest mechanical advantage

– most distance per pedal

Lowest Gear



– easiest to pedal

– highest mechanical advantage

– least distance per pedal

The mechanical advantage of your gear is found by finding the number of teeth used on the front and back sprockets. Then, divide as follows:

$$\text{M. A.} = \frac{\text{teeth on back sprocket}}{\text{teeth on front sprocket}}$$

Look at this example based on the author's bike.

Freewheel Gears (rear) Number of Teeth	Chainwheel Gears (front) Number of Teeth
smallest – 14	
17	
20	40
24	52
largest – 28	

1. a. How many speeds are on this bike? ____________

   b. What is the mechanical advantage of high gear?

   ____

   ____

   ____

c. What is the mechanical advantage of low gear?

____

____

____

2. All the mechanical advantages are less than one. What does this mean?

____

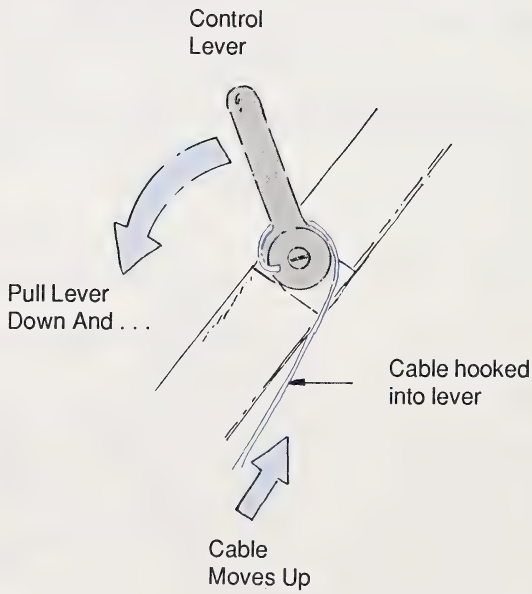
____

____

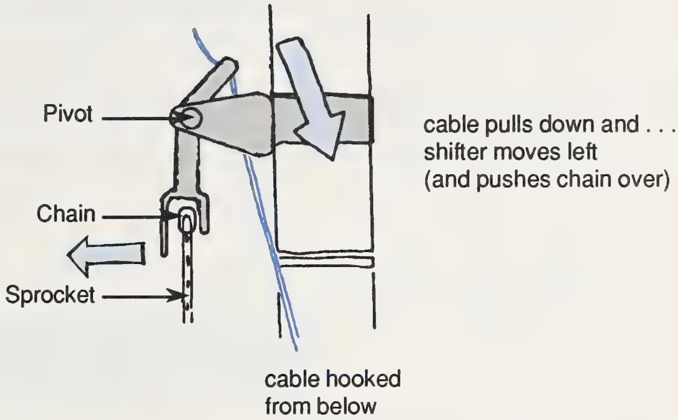
Hint: Look back to Section 1 of this module.

Check your answers by turning to the Appendix, Section 3: Activity 4.

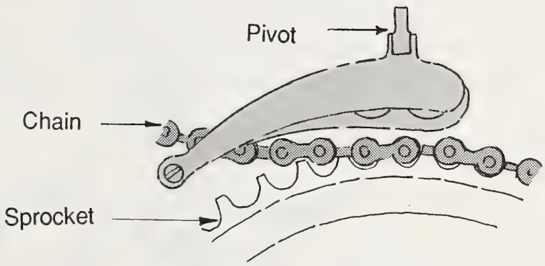
Here's how the gear changers work.



Front View of Derailleur



Side View



3. a. What type of lever is the control lever?

____

b. There is another lever in the derailleur. Describe how it works.

____

____

____

____

4. The control lever pulls or pushes a cable which pushes the chain off one gear and onto another. Can you see why you change gears while pedalling? What would happen if you change gears while coasting?

____

____

____

____

____

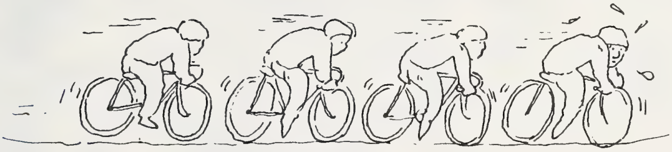
Check your answers by turning to the Appendix, Section 3: Activity 4.

Activity 5: Friction

wind resistance - a form of friction caused by moving an object through air, or moving air past an object

The toughest thing to fight when cycling is the wind. You and your bike must push through the air creating air friction, or **wind resistance**.

It's amazing how fast a bike can go when there is no wind at all. The world speed record for a bicycle is over 240 km/h! The rider rode in an enclosed shelter moving behind a racing car. His wind resistance was zero.



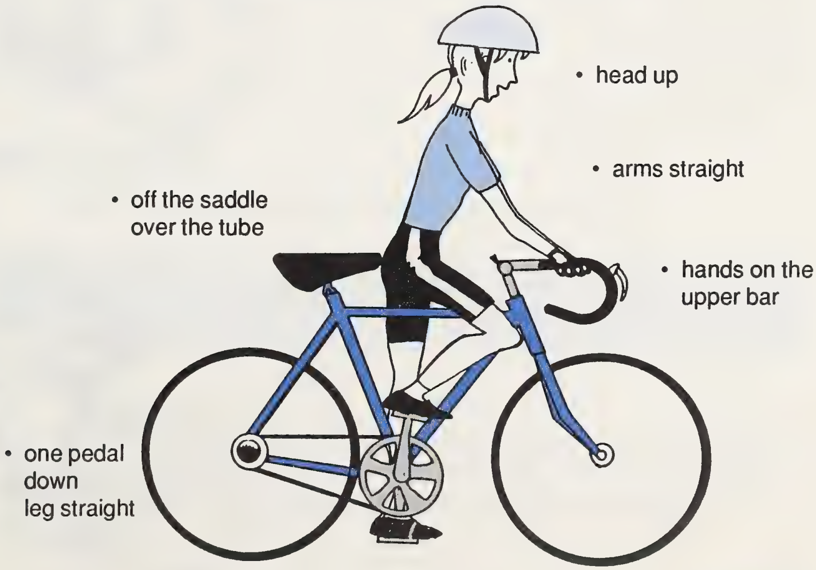
drafting - cycling close behind another cyclist, car, or other vehicle to reduce wind resistance

The three riders at the back are **drafting**. Their wind resistance is less because they are riding in the first rider's wake. They use up to 30 percent less energy than the front rider does.

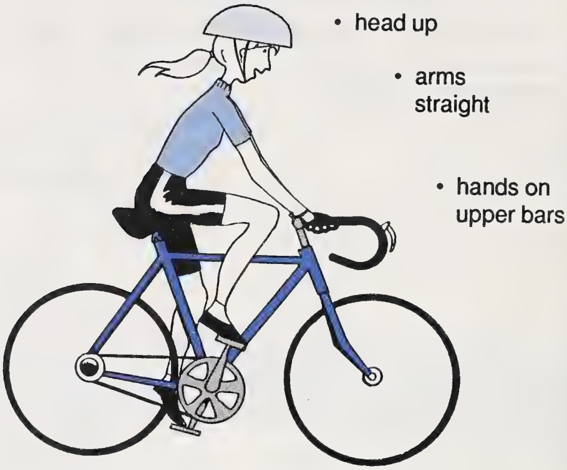
If you're not a racing cyclist, then you rarely get to draft someone to decrease your wind resistance. What else can you do? The answer is found in yourself. Approximately 70 percent of a bike's wind resistance is the rider's body. If you ride in a full tuck position (not recommended in traffic) you have 25 percent less wind resistance than if you ride upright.

Riding Positions

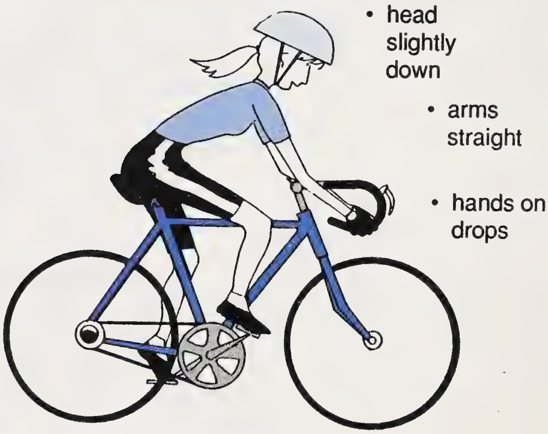
Standing – Lots of Wind Resistance



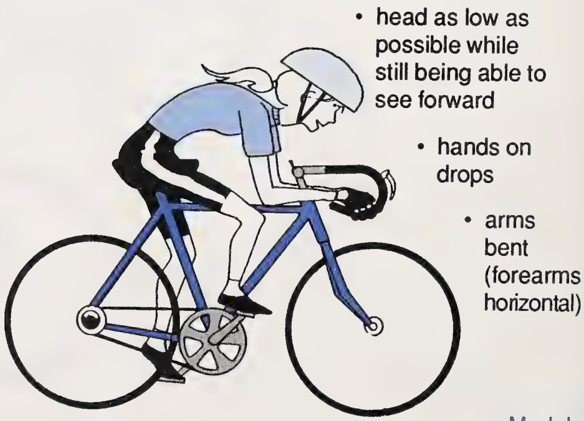
Touring – Less Wind Resistance



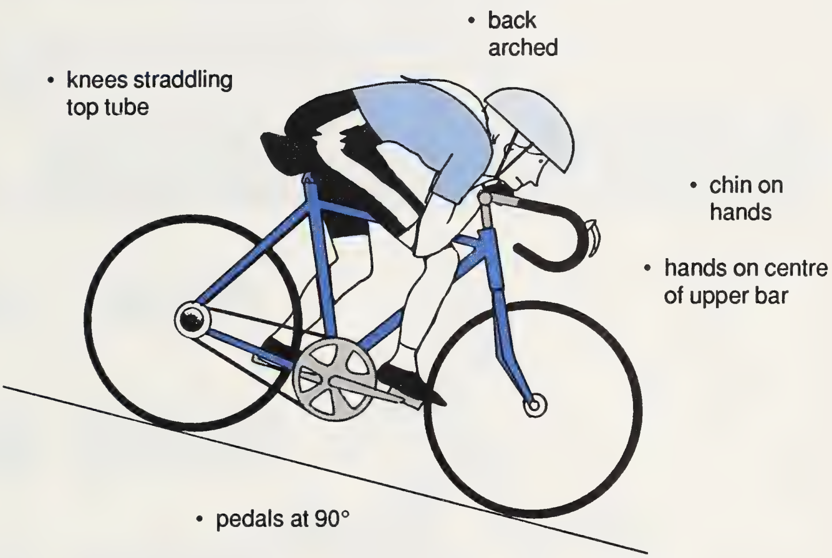
Racing – Even Less . . .



Crouching – Still Less . . .



Hill Descent – Least Wind Resistance



1. How does speed affect wind resistance?

____

____

2. As the body positions get lower, the wind resistance goes down. Why?

____

____

____

Hint: Think about how these positions look head-on.

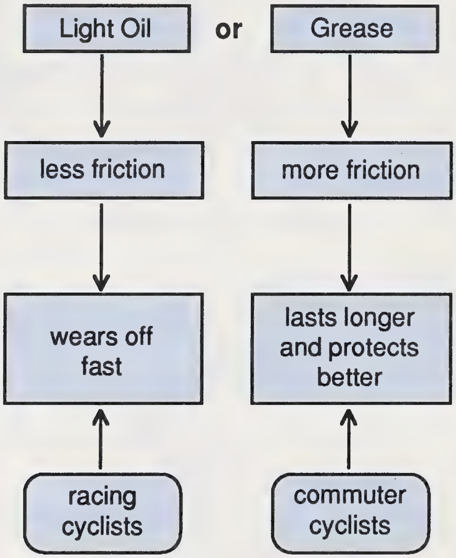
Check your answers by turning to the Appendix, Section 3: Activity 5.

If you are going about 30 km/h on your bike, you use energy. Power is the rate of using energy (see Section 2 of this module). You need to keep up a power rate of 200 W if you are in the touring position at this speed.

You only need to maintain 160 W in the crouching position. (A healthy adult can keep up a power of about 75 W continuously.)

Approximately 80 percent of all the friction on a bike is wind resistance (at 30 km/h). That still leaves a fair bit of friction that comes from gears, tires, and pedals. To reduce friction in these parts you have to keep the bike in tune.

To Lower Mechanical Friction at the Axles



Your tires cause friction when they contact the road. Keep them inflated as high as possible to reduce this type of friction.

3. Why would racers prefer light oil to grease?

____

____

____

4. Why would a city driver be better off using grease?

Check your answers by turning to the Appendix, Section 3: Activity 5.

Activity 6: Going for a Ride

Investigation: Cycling Strategies

This is an investigation in which you must actually go for a ride on your bike. It is an investigation in which you develop a strategy for cycling.

Materials You Need

- bicycle
- watch or clock

Steps to Follow

STEP A

Set up a course to ride. It should be at least 3 km long. (1.5 km out and 1.5 km back is okay.) Ideally, it should have at least one hill.

STEP B

You will ride the course as fast as you can using two strategies.

- Ride all the way in the highest gear you can.

or

- Change gears constantly to keep a rhythm going.

STEP C

Record your time for the course, and record how tired you feel afterwards in the observations section that follows.

Notes:

Strategy 1 – The gear that you use on the most difficult part of the course is the one to keep using. If you have a flat course with one difficult hill, use two gears, but include that information in the observations.

Strategy 2 – Having a rhythm means pedalling at a constant rate. Try the rate of 1 pedal per second (count 60 in 1 minute). Count one each time your right knee comes up. You must change gears to keep up this rate. Hills, wind changes, and fatigue can all be reasons to gear up or down. **Keep the rate constant.**

Observations

1. Describe your course.

   length in kilometres: ______________________________

   description: ______________________________

   ____

   ____

   ____

2. Strategy 1 – One (Or Just a Few) Gear(s)

   a. time to complete: ______________________________

   b. how you feel afterwards: ______________________________

   ____

   ____

3. Strategy 2 – Constant Rate of Pedaling

   a. time to complete: ______________________________

   b. how you feel afterwards: ______________________________

   ____

   ____

Conclusion

4. Based on your trials, which is the better way to cycle?

____

____

____

____

5. List one advantage and disadvantage of each strategy in the following chart.

	Constant Gear	Constant Pedalling
Advantage		
Disadvantage		

Check your answers by turning to Appendix, Section 3: Activity 6.

Follow-up Activities

If you had difficulties understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

Extra Help

In order to understand a complex technology, it is useful to look at each part separately and then the whole thing together. Principles of more basic technologies are usually found as parts of complex ones.

For example:

Electric Guitar

strings	↔	sound, simple machines
pickup	↔	electromagnetism (generator)
amplifier	↔	solid state electronics
speaker	↔	electromagnetism (motor)

Bicycle

gear	↔	simple machines
brakes	↔	simple machines
riding style	↔	friction

Once you have a complex device, it's useful to test it and decide how good it is. If you know the parts, it's possible to troubleshoot (and fix) the system.

1. Which complex device from the right has the parts listed on the left?

	Parts	Complex Device
_______	lens, motor, shutter	A. car
_______	lobe, three bones, cochlea	B. camera
		C. human ear
_______	engine, transmission, exhaust	D. human eye
_______	lens, cornea, retina, optic nerve	

2. Here are some subsystems of a car.

- engine
- transmission
- brakes
- carburetor
- power train
- exhaust
- electrical
- fuel

Which system needs fixing if

a. it can't stop? ____________________

b. it won't shift gears properly? ____________________

c. it won't "turn over" when starting? ____________________

d. you smell gases when driving? ____________________

Enrichment

1. Tune up your bicycle yourself. There are many books available that tell you how.

2. Research how a microphone works

3. Research how a transistor works.

Conclusion

You learned that a complex technical device is the sum of a number of subsystems. You looked at a device and its systems to learn how it worked. You tested the device by trying to fix problems, or by investigating the application of its principles.

Assignment Booklet

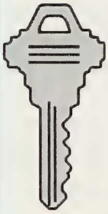
ASSIGNMENT

Turn to your Assignment Booklet and do the assignment for Section 3.

MODULE SUMMARY

Complex technology is based on simpler technology. This module looked at two simpler technologies that are often used in more complex ones. Almost everything you do uses technology; it's only a matter of looking to find it.

Appendix



Glossary

Activities

Extra Help

Enrichment

Glossary

A.C. (Alternating current)	• current that reverses its direction many times per second
Amperes (amps)	• units that measure electric current, or the rate of flow of electrons
Battery	• a device that produces electric current by changing chemical energy to electrical energy
Chainwheel	• set of gears at the front of a bike
Circuit	• a loop of electricity; a path for electrons to follow
Circuit breaker	• a device that breaks a circuit if too much electricity flows
Circumference	• the distance around a circle
Closed circuit	• a complete circuit; turned on
Conductor	• a substance that lets electrons (electricity) flow through it
Current	• the rate at which electricity flows, measured in amperes
D.C. (Direct current)	• current that flows in one direction
Derailleur	• a gear-changing system that moves the chain from one gear to another
Drafting	• cycling close behind another cyclist or vehicle to reduce wind resistance
Efficiency	• measure of the energy loss of a machine; 100 percent efficient = no energy loss
Effort	• force exerted by a person using a machine
Electric charge	• an excess or shortage of electrons in the same location
Electron	• a negatively charged sub-atomic particle responsible for electricity
Electromagnet	• an iron core that turns magnetic when a current travels around it

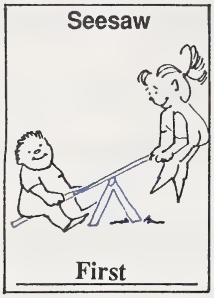
Electromagnetic	• a magnet produced by an electric current flowing around an iron core
Electromagnetism	• magnetism produced by a current of electricity
Energy	• ability to do work, measured in joules
Freewheel	• a group of gears at the back of a bicycle
Force	• a push or a pull usually measured in newtons A baseball weighs about 1 N.
Friction	• a force caused by surfaces sliding past each other (Air is a surface.)
Fulcrum	• the balance or pivot point of a lever
Fuse	• a circuit breaker that uses the heat from a current to melt a metal strip to break the circuit
Gear	• a toothed wheel connected to others either directly with a chain or belt
Generator	• a device that converts mechanical motion into electricity
Inclined plane	• a simple machine consisting of a flat surface set at an angle
Insulator	• a substance that does not allow electrons (electricity) to flow through it
Joule	• standard unit of energy It is equal to one newton of force exerted over distance of one meter.
Kilowatt hour	• energy unit used by electric utilities
Lever	• a rigid bar turning on a pivot point (fulcrum)
Lodestone	• naturally occurring magnet (iron mineral)
Mechanical advantage	• a measurement showing how much easier your work is; ratio of resistance ÷ effort for any simple machine
Motor (electrical)	• a device that converts electrical energy into mechanical motion
Open circuit	• circuit that has a break in it; turned off

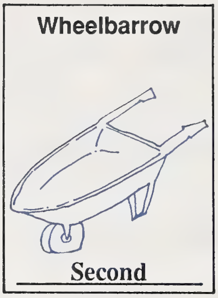
Pickup	• a device that turns string vibrations into electric signals
Power	• the rate of doing work; the rate of energy use The standard unit of power is the watt. One watt is one joule per second.
Pulley	• a wheel with a rope around it
Resistance	• the force you try to overcome with a machine
Screw	• an inclined plane wrapped around a shaft
Turbine	• a wheel that spins rapidly on a vertical axis, powered by water or steam
Transistor	• a solid state device that varies the flow of electricity through it
Transformer	• a device that changes the voltage of an A.C. electric current
Volts	• units that measure the electric potential difference (energy difference between two parts of a circuit)
Watt	• the standard unit of power One watt is one joule of energy per second.
Wedge	• an inclined plane used as a moving part to exert a force at right angles to its motion
Wheel and axle	• a type of lever consisting of two wheels on the same axis
Wind resistance	• a type of friction caused by moving an object through air, or moving air past an object
Work	• the application of a force through a distance
Worm gear	• a screw thread that meshes with regular gears

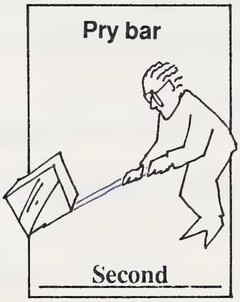
Suggested Answers

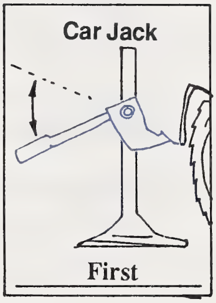
Section 1: Activity 1

1. These are all pictures of levers. Classify them as first-class, second-class, or third-class levers.









2. The handle end is easier to push.

3. The handle end is longer. It has an advantage over the eating end.

4. The handle end is longer, giving it the advantage over the eating end.

Investigation: Is There a Relationship Between the Distance from a Fulcrum and the Effect of the Force at That Position?

Observations

Number of Weights	Distance from Fulcrum (cm)	Number of Weights	Distance from Fulcrum (cm)
8	20 *	8	20
4	40	8	20
6	27	8	20

*Your measurements should be close to these.

Conclusions

Weight × distance should always equal 160 or be close to that number.

5. Resistance arm (500 N)(50 cm) = 25 000 N • cm
   Effort arm (250 N)(100 cm) = 25 000 N • cm

6. $\text{M.A.} = \dfrac{\text{resistance}}{\text{effort}}$ $\quad 10 = \dfrac{3000}{\text{effort}}$ $\quad$ effort = 300 N (about 30 kg)

   You would have to exert a force of 300 N on the jack to lift the car.

7. a. wrench
   b. yo-yo
   c. dimmer switch

8. **Toolbox**

   Possible answers are

   - hammer – less than one when pounding
     – greater than one when pulling nails out
   - wrench – greater than one
   - screwdriver – greater than one
   - pliers – greater than one pinching, and greater than one turning

   There are others as well.

9. **Kitchen**

   Possible answers are

   - bottle opener – greater than one
   - can opener – greater than one
   - meat mallet – less than one
   - toenail scissors – greater than one
   - paper scissors – less than one
   - nutcracker – greater than one

   There are others as well.

Section 1: Activity 2

1. The mechanical advantage of an inclined plane is greater than one.

Investigation: To Find the Mechanical Advantage of an Inclined Plane

Be sure to pull with a slow, **steady** hand. The elastic will not stay at one length, so you must estimate the average.

Conclusion

2. The stretch gets longer as the ramp gets steeper.

3. Yes, when the ramp is very steep.

4. There is more work done with the ramp.

5. Friction is responsible for the extra work done with the ramp.

6. $\dfrac{\text{resistance}}{\text{effort}} = \dfrac{500\text{ N}}{250\text{ N}} = 2$

   The ramp has a mechanical advantage of 2.

7. $\dfrac{\text{length}}{\text{height}} = \dfrac{3\text{ m}}{1\text{ m}} = 3$

   In theory, the mechanical advantage should be 3.

8. **Toolbox**

   Possible answers are

   wedge – saw blade, tin snips blade, chisel
   screw – screws, bolts, crescent wrench tightener, drill bit

9. **Kitchen**

   Possible answers are

   wedge – knife blades, scissors blades, can opener blade, spatula
   screw – corkscrew, jar lid (any twist lid)

Section 1: Activity 3

1. a. The pulley (wheel) is attached to the branch. Otherwise, the branch acts as the wheel.

   b. The wheel is easier to use.

   c. There is much less friction using the pulley.

2. a. The other person's chair will move towards your chair.

   b. The rope going around the chair leg is like a moveable pulley. The force you exert is multiplied by two on the other chair.

3. Putting a larger gear on the motor and a smaller one on the sign will make the sign move faster than the motor.

4. Block and tackle systems have large mechanical advantages. This is necessary to pull in a sail against the large force of the wind.

Section 1: Follow-up Activities

Extra Help

1. a. lever (2nd class)

   b. wheel and axle

   c. wedge

   d. inclined plane

   e. screw

2. $$\text{M.A.} = \frac{\text{resistance}}{\text{effort}} = \frac{3500\text{ N}}{250\text{ N}} = 14$$

   You need a mechanical advantage of 14.

3. a. Effort = 50 N
   left side [100 N(10 cm) = 1000 N • cm]
   right side [50 N(20 cm) = 1000 N • cm]

   b. ratio of diameters $\frac{24\text{ mm}}{6\text{ mm}} = 4$

   M.A. = 4

   c. $\text{M.A.} = \frac{\text{length}}{\text{height}} = \frac{4\text{ m}}{1\text{ m}} = 4$, so $100 \div 4 = 25$ N

   The force needed to push a 100 N weight up the ramp is 25 N.

   d. $\text{M.A.} = \frac{\text{length}}{\text{height}} = \frac{18\text{ cm}}{2\text{ cm}} = 9$

   e. fixed pulleys

   f. count teeth: $\frac{\text{large}}{\text{small}} = \frac{9}{5} = 1.8$

   The gear ratio (large to small) is 1.8:1.

Enrichment

1. I can't do it!

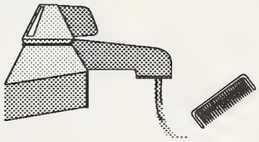
2. This depends on your bike. It's common for different combinations to have the **same** gear ratio. A ten-speed doesn't have ten **different** gears.

Section 2: Activity 1

1. a. The water is attracted to the comb.

   b. You see tiny sparks.

   c. You get a shock.



2. The extra electrons from the negative charge will jump over to make up for the lack of electrons on the positive charge (a spark occurs).

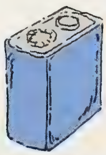
3. They would repel (push away from each other).

4. Nothing, glass is an insulator. No electrons move, so the charges remain on the balloons.

5. The extra electrons on the negative balloon go through the copper rod to the positive balloon (it's a conductor) until the number of electrons even out.

Section 2: Activity 2

1. It probably has 1.5 volts (a bit less if it's a nickel-cadmium rechargeable battery), 6 volts if it's a lantern battery, or 9 volts if it's one of these.



2. The bulb will burn out. The filament will get too hot and melt.

3. The circuit is open. The broken filament acts like a switch to break the circuit.

4. a. voltage

   b. amperage

Investigation A: A Quick Flashlight

STEP B

OBSERVATION

The bulb does light up. Electricity goes up the bottom of the bulb, through it, and out the side.

Conclusions

No, you did not need a wire. The foil is as good as a wire.

Investigation B: Flashlight Parts

Different flashlights vary. Look for a metal contact on the bottom of the battery (or batteries). The bulb usually rests on the top of the battery. The case itself can be the wire back from the bulb.

Section 2: Activity 3

1. The stove uses more current so that it can get hotter.

2. a. $6\text{ kW} \times 3\text{ h} = 18\text{ kW} \bullet \text{h} \times 5.5¢ = 99¢$

   b. $100\text{ W} = 0.1\text{ kW} \times 3\text{ h} = 0.3\text{ kW} \bullet \text{h} \times 5.5¢ = 1.65¢$ (cheap!)

3.

Appliance	Volts	Amps	Watts
toaster	120	7.5 - 10.4	900 - 1250
electric kettle	120	10.4 - 12.5	1250 - 1500
stereo component	120	0.0417	5
60W light bulb	120	0.5	60
electric heater	120	6.25 - 12.5	750 - 1500
electric drill	120	2 - 3	240 - 360
radio (plug in type)	120	0.5	30 W per channel (60 total)
circular saw	120	6 - 9	720 - 1080

Note: Your values may differ from these. These are ballpark figures.

4. Total watts = 1700 W
   Total amps = 14.2 A
   The breaker won't blow. It is close to blowing, but the circuit should take the load.

Section 2: Activity 4

Investigation: Building a Compass

Observations

Fill the glass full. Sooner or later the float moves to the centre.
If you can't find a moving magnet, stroke the needle over a fixed one (in a speaker, refrigerator door, etc.).

1. a. The needle points close to north-to-south.

   b. The needle is off to the east.

Investigation: Electromagnetism

Use an AA size battery, or smaller if possible. A D-cell battery heats the aluminum quite fast.

2. The compass needle moved away from the N-S direction when the foil came close to the needle.

3. It went back to N-S when contact with the battery was broken.

4. The needle moved away again.

5. They have two types of things in common (charges and poles); opposites attract, like things repel.

6. a. repel

   b. attract

   c. attract

   d. repel

7. Lifting scraps of metal (old cars) and dropping them can be done with an electromagnet. (Any answer that indicates that a magnet is used to pick something up and then drop it is acceptable.)

Section 2: Activity 5

1. electric current

2. move

3. motor

4. generator

5. You would connect the motor's shaft to something that could turn it. This would produce electricity.

Section 2: Follow-up Activities

Extra Help

1.

things that give us electricity	a. **electrons**
b. **too many electrons**	negative charge
too few electrons around	c. **positive charge**
two negative charges close will	d. **repel**
e. **lets electrons move**	conductor
won't allow electrons to move	f. **insulator**

2. Examples of insulators are glass, air, pure water, plastic, and rubber.

3. Examples of conductors are aluminum, copper, dirty water, or any metal.

4. a. No, the light socket isn't connected.

   b. Yes, the light will go on.

   c. No, the switch is open.

   d. No, the bulb is burned out.

5. $\text{volts} \times \text{amps} = \text{watts}$

   $120 \times 4 = 480 \text{ watts}$

6. $\text{volts} \times \text{amps} = \text{watts}$

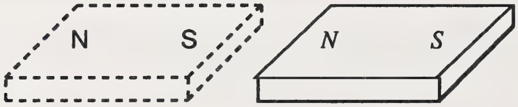
   $120 \times \text{amps} = 80$

   $$\text{amps} = \frac{80}{120} = 0.67 \text{ amps}$$

7. $1500 \text{ W} = 1.5 \text{ kW} \times 8 \text{ hours} = 12 \text{ kW} \bullet \text{h}$

8. Some devices are stoves, ovens, toasters, fuses, circuit breakers, and heaters, as well as many other devices.

9.



10. The electromagnet shows that electric currents have magnetic fields.

11. Electromagnetism is the term used when magnetism and electricity are two parts of one thing.

12.

Generator Effect	Motor Effect
A moving **wire** in a **magnetic field** produces **electricity**.	Running **electricity** through a wire near a **magnet** makes the wire **move**.
A generator turns **movement** into **electricity**.	A motor turns **electricity** into **movement**.

Enrichment

1. Dirty water conducts electricity quite well. However, it isn't the water that's the conductor. Substances in the water, such as minerals, work as conductors. Wet electrical devices can kill people if the electricity is grounded through them.

2. Turn a breaker off and check which plug-ins and lights don't work. Use a lamp as a tester.

3. It takes careful adjusting (bending) of the clips to fine-tune the alarm.

4. Don't put too much current through your motor or you will melt the insulation and burn it out. It takes a lot of fiddling to get it to work – don't give up too easily.

Section 3: Activity 1

1. a. All the strings are the same length.

   b. The thicker the string, the lower the pitch.

2. • The worm gear turns many times to make the main gear turn once.
   • The knob on the end is a wheel and axle with the worm gear (much like a screwdriver).

3. The Law of Tension and the Law of Thickness have been used to tune the guitar.

4. a. Pressing your finger behind a fret pins the string to a fret, thus making the string shorter.

   b. By doing this, the pitch will be raised.

   c. The Law of Length causes this to happen.

Section 3: Activity 2

1. No, nylon is an insulator. The generator effect needs a metal wire (string) moving in a magnetic field.

2. No, the amplifier can't convert electricity into sound. A speaker is required to convert the electricity into sound. Some amplifiers have speakers.

Section 3: Activity 3

1. A: pickup

   • turns string vibrations into electric signals

   B: amplifier

   • boosts weak guitar signal
   • sends a strong signal into speakers

   C: speaker

   • turns electric signal back into sound

2. a. The trouble is probably in the speaker. This could be due to a loose cord connection, a bad cord, or the amplifier may be broken in that one connection.

   b. The trouble is probably in the amplifier or guitar. This could be due to an unplugged amplifier, or the guitar cord could be faulty or badly connected.

   c. A poor connection from the guitar to the amplifier is the probable cause. Check the cord connections or replace the cord.

   d. Carry extra cords! Back-up amplifiers and speakers are expensive, and it is time-consuming to replace them.

Section 3: Activity 4

1. a. There are ten speeds on this bike.

   b. $\frac{14}{52} = \text{about } 0.27$

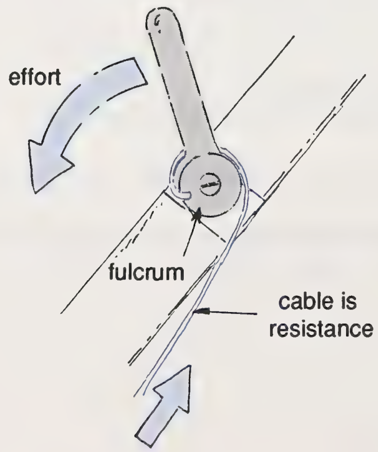
      The M.A. is 0.27.

   c. $\frac{28}{40} = 0.70$

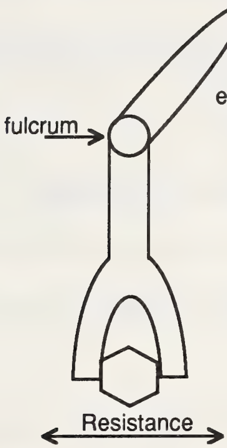
      The M.A. is 0.70.

2. If the M.A. is less than one, you gain distance and lose force.

3. a. The control lever is a wheel and axle or second-class lever.



b. The changer pivots on a fulcrum. The cable supplies the effort, and the chain puts up the resistance (first-class lever).



4. The chain won't slip off the gear unless you push **hard**. If you change while coasting, it will wreck the gear and chain. (If the gears are turning while you shift, they will slip off one gear and onto the next.)

Section 3: Activity 5

1. As speed increases, so does wind resistance.

2. As you go lower, you expose less area to the wind.

3. Light oil has less friction and only has to last for the race.

4. A city driver would be better off to use grease, because it increases protection and decreases maintenance. Loss of friction isn't crucial for commuting.

Section 3: Activity 6

Investigation: Cycling Strategies

Observations

1. You will decide the length of the course. Just be sure to write it down. Description: Include whether your course is hilly or level; if there are traffic signs or lights; and what type of surface you are riding on (pavement, dirt, etc.).

2. Strategy 1 – One gear

   a. time to complete: The time taken to complete the course will depend on you.

   b. how you feel afterwards: Use phrases to describe how tired you are (if you are sweating, if you have any muscle cramps, etc.). If you know how, take your pulse rate, too.

3. Strategy 2 – One pedal speed

   Rate of pedalling – 60 pedals per minute suggested (Racers can do 90.)

   a. time to complete: The time taken to complete the course will depend on you.

   b. how you feel afterwards: Describe as in Strategy 1.

Conclusion

4. You make the decision. Time might be your deciding factor, but also consider how tired you were afterwards.

5.

	Constant Gear	Constant Pedalling
Advantage	• simple, no gears to worry about • safe, can watch traffic better	• most efficient method, uses the least energy • easier on knees
Disadvantage	• one gear wears out faster • harder on your body if you have hills, stops, etc.	• takes quite a bit of practice • distracts you from traffic until you're good at it

You may have found other advantages and disadvantages as well.

Section 3: Follow-up Activities

Extra Help

1. B lens, motor, shutter

   C lobe, three bones, cochlea

   A engine, transmission, exhaust

   D lens, cornea, retina, optic nerve

2. a. brakes

   b. transmission

   c. electrical

   d. exhaust

Enrichment

1. One book is *Anybody's Bike Book* by Tom Cuthbertson. It is published by Ten Speed Press.
2. Try to find out how it turns sound into electricity. The rest is the same as the guitar.
3. Look up semiconductors; transistors use them.

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